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AUG 31 1906

SCIENTIFIC AMERICAN
SUPPLEMENT. No. 1600

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Scientific American, established 1845.
Scientific American Supplement, Vol. LXII., No. 1600. NEW YORK, SEPTEMBER 1, 1906. Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

THE THEBES RAILROAD BRIDGE.*

By CHARLES ALMA BYERS.

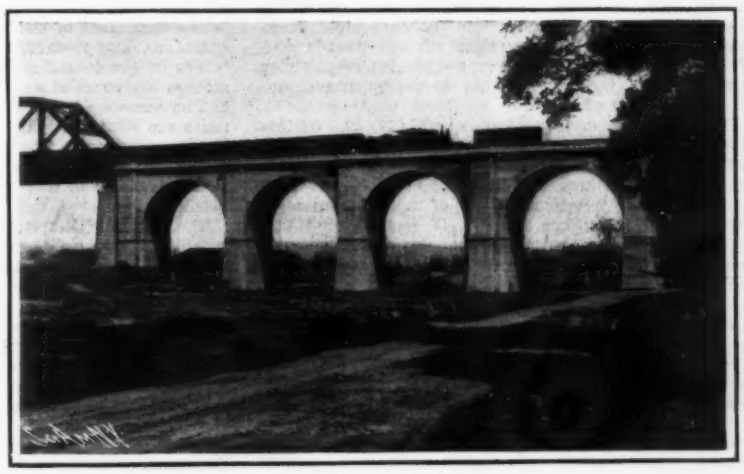
As a valuable aid to rapid transportation for the region affected, and as a typical work of modern railroad bridge construction, the new railroad bridge recently finished at Thebes, Ill., spanning the Mississippi River at a point one hundred and thirty miles south of St. Louis and twenty-six miles northwest of Cairo, is entitled to far more than passing consideration. It is a bridge that, during its construction, has received the attention of engineers in all parts of the United States, and now that it is complete, even to the third and last coat of paint, a brief review of the work will prove of general interest.

The bridge was built under the direction of the Southern Illinois and Missouri Bridge Company, and for the purpose of connecting the Illinois Central, the Chicago & Eastern Illinois and the St. Louis Southwestern railroads on the Illinois side with the 'Frisco system, the Iron Mountain, and the St. Louis Southern railroads on the Missouri side of the river, thereby doing away with the unsatisfactory transfer of trains by boat. The construction of the bridge, providing for spans of specified lengths, was authorized by an act of Congress, January 26, 1901, and on May 25, 1905, it was formally dedicated, tested and opened to railroad traffic. Although work on its construction was practically in progress for about four years, the time really required for the bridge's completion may be given as only two years and seven months.

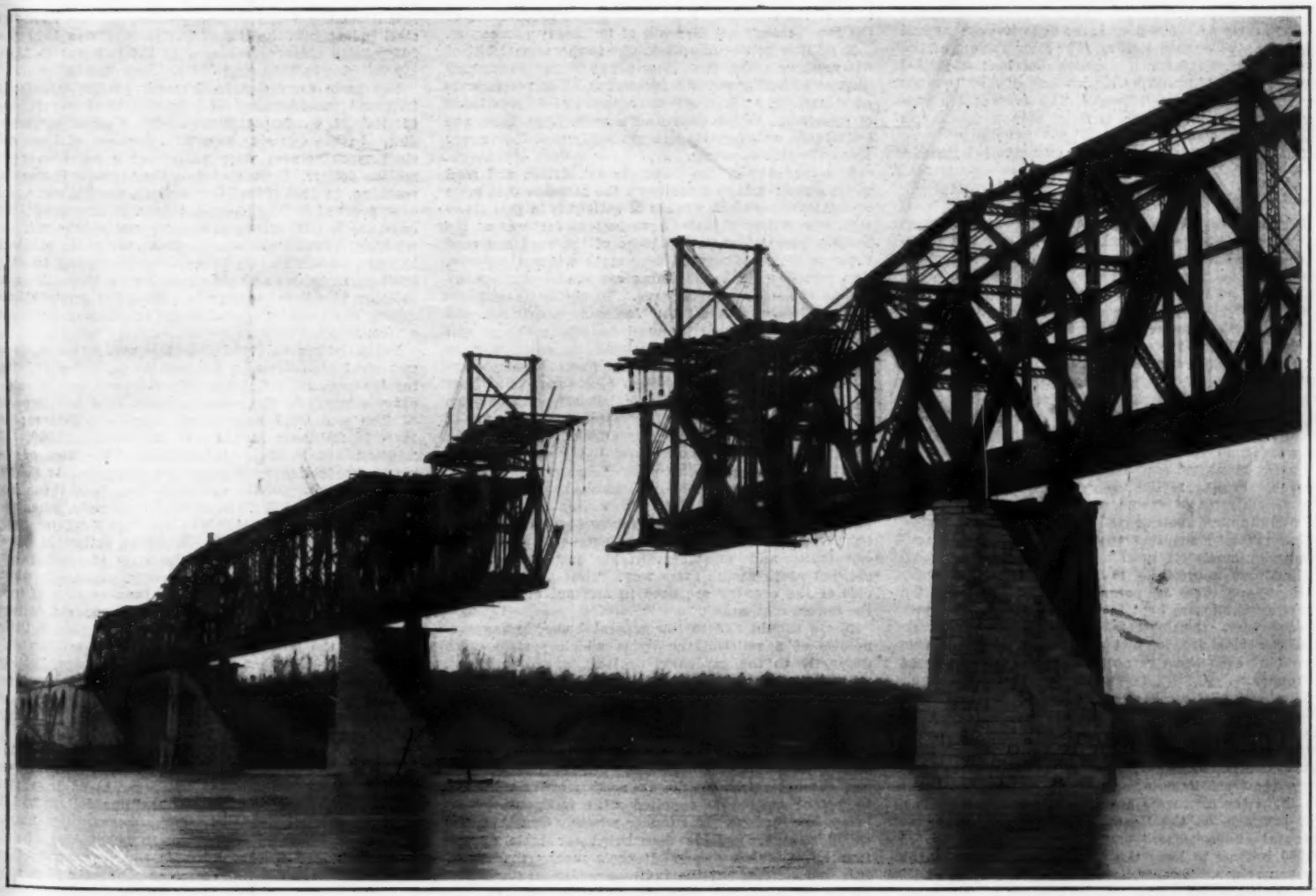
The Thebes bridge, as it is commonly called, is one of the largest, in point of long, heavy spans, across the Mississippi River or any other stream in the United States, and is surpassed by only two bridges in foreign countries. No bridge in this country, except the one across the Mississippi at Memphis, has a longer trussed span, not an arch, than has the Thebes bridge, the channel span of which is 671 feet long. The bridge supports a double track, and is a continuous steel structure of five spans. The channel span forms the center, and the lengths of the two spans on either side of it are 521 feet 2 inches, while the two end spans

*Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

LOOKING THROUGH ONE OF THE SPANS.



THE MASONRY ARCHES.



BUILDING THE BRIDGE FROM BOTH SIDES TOWARD MIDSTREAM.

THE THEBES RAILROAD BRIDGE.

are each 518 feet 6 inches. This steel superstructure is therefore 2,750 feet 4 inches long. The trusses are of the pin-connected type, and they are supported on six piers of ashlar masonry—a stone facing, covering concrete—founded on solid rock, five of which have pneumatic caisson footings.

The trusses of the bridge are 32 feet apart, with horizontal and vertical train clearances of 27 feet 8½ inches and 22 feet 6 inches, and the top and bottom chords form part of systems of lateral X-bracing, with sway bracing and transverse vertical planes and portals in the planes of the inclined end posts. The lengths of the free span panels are each 32 feet 6⅞ inches, and in other parts, being sub-divided by vertical posts and half diagonals to reduce in length the floor panels, are 30 feet 6 inches long.

The total weight of the superstructure is 26,880,000 pounds. The weight, per lineal foot, of the free spans is 11,560 pounds; of the suspended spans, 7,720, and of the cantilever arms, 11,650.

The bridge is approached at both ends by concrete arches—five on the Illinois side and seven on the Missouri side. The length of each of the former is 65 feet, and of the latter, six are 65 feet long and one 100 feet long. These concrete arches are made of Portland cement concrete, of which they contain 35,000 cubic yards. The roadbed on both approaches is double-track, ballasted, and laid with 85-pound rails.

The river at the point crossed is about 2,700 feet wide between high-water banks and 2,400 feet between low-water banks, and has an ordinary depth of 50 feet. The low-water banks are each from 10 to 15 feet above low water, and the high-water banks from 35 to 40 feet above low water. The steel superstructure is elevated on its piers so as to leave a clearance of 65 feet above extreme high water, so that river boats may pass under it at any time without danger, and from the bottom of the lowest foundation of any pier to the top of the highest point of the superstructure it is a distance of 231 feet.

The total cost of this bridge was $2,800,000. Of this amount $1,400,000 was for the steel superstructure, $600,000 for its piers and foundations, and $300,000 for the concrete arch viaducts. To many it will seem that this is an enormous outlay of money for a mere bridge, and it is; but when it is realized that this bridge forms a link between so many railroad systems, and that it is crossed daily by almost a thousand cars, the importance of the structure and the wisdom of the enterprise can be quite readily comprehended. To assist in this direction, it may be said that during the first four months that the bridge was in use 2,856 freight and passenger trains crossed it. This is an average of 714 a month, or 24 a day. The highest number of cars that have crossed it any single day was 1,024.

The testing of the bridge on the day of its dedication was made with twenty-eight large-size locomotives of modern type, which were furnished by five different railroad companies. They were run slowly over the bridge from one end to the other, and under this load of nearly 8,000,000 pounds the deflections were well within the prescribed limits. The floor system of the bridge is designed for a concentrated load of 50,000 pounds, to be followed by a trainload of 5,000 pounds per lineal foot of each track. The trusses are proportioned for eighty per cent of this weight. The steel has an elastic limit of 37,000 pounds, with an ultimate strength throughout of about 70,000 pounds.

RAILROAD HOUSEKEEPING ECONOMIES.

THE housekeeping side of a great railroad is generally kept in the background, and the annual expenditures and income from this source seldom figure in the year's balance sheet which the public sees in print. Under the general heading of "minor income and expenditures," however, there appear items which might well excite the interest and amusement of the casual student. Whatever else may be said about our great railroad systems, good or bad, they have never been accused of lack of careful, systematic operation in the expenditures of the great sums of money which must annually be made for efficient maintenance. There is no stricter and better business school from which a young man or woman can graduate than one of the great trunk railroad systems which criss-cross our continent in all directions.

A single railroad system will have upward of four or five hundred stations along its different routes, which must be supplied with certain household articles and utensils for good housekeeping. Every modern railroad appreciates the value of clean, sanitary stations, and these temporary stopping places for the traveling public are kept in better condition each succeeding year. Greater comforts and luxuries are supplied by rival roads, and the expenditures in this direction are directly noticeable in the increased patronage.

The "general housekeeper" of a great trunk railroad line is most frequently a man, and his business is to manage the stations, supplying them with all needful articles, and closely watching the waste to see how a saving can be effected. Under his bureau control there come numerous items of apparently small concern, but which in the aggregate amount to considerable sums. For instance, on the Santa Fé system last year, the "general housekeeper" purchased and distributed 26,000 brooms to keep the stations and offices of the company clean. Twenty thousand boxes of soap, 25,000 scrubbing brushes, and a similar number of hand-mops figured in the expenditures. The housekeepers of the individual stations and offices represent a formidable army. Upward of 10,000 of these were employed off and on last year by the Santa Fé road. At many of the small stations, the agent is his own housekeeper, ticket seller, telegrapher, and general freight agent; but at the larger stations scrubbers and cleaners are employed by the year.

The employees and officials of a big road must have pens, ink, paper, and even pins. Last year the pin item on the Santa Fé was no inconsiderable one. The total weight of the pins bought by the general housekeeper and distributed to the employees was 3,000 pounds. Forty thousand pens were also used, and fifty barrels of ink. There were enough lead pencils used to reach from Chicago to New York, and half way back again, if they were placed end to end.

An interesting question that comes up in every household is the disposition of the waste. The railroad housekeeper is careful to study out any economy, and the waste along the whole line is economically disposed of. Waste pins, pens, paper, old brooms, mops, bottles, and worn-out machinery of locomotives are gathered up along the route and sold for junk or "old scrap."

A small item, one would say, but a large one when considered in its true light. From waste paper alone last year the railroad above realized a profit of $5,000. Pens, shingles, and nails proved of important value. The total value of the "scrap heap" reached the enormous sum of $1,250,000. Of course the greater part of this waste came from the worn-out locomotives and cars which are sent to the scrap heap after they have ceased to be of further value to the company. But on the small household items mentioned, upward of $100,000 were realized. Everything is saved, and everything is economically disposed of. Even the ashes are sold or utilized for improving the roadbed.

The equipment of stations to-day with slot machines, literature, and restaurants has greatly increased the labors of the housekeeping department. In some instances the concessions are sold to private companies, but on some roads the rights to sell articles along the route are retained by the transportation company. On the Santa Fé route last year $11,500 were taken in the penny slot machines for chewing gum. This meant that a million and more pennies were dropped into the machines.

The supply of literature by the railroad company is enormous. Upward of five thousand train boys hawked the periodicals through the cars as licensed sellers, and half as many more sold books and magazines at the different stations. Several million dollars were taken in last year on the Santa Fé through this source. The distribution of literature over the whole route is a matter of exact business routine, which is managed entirely by a single head.

Candies, fruit, sandwiches, and similar edibles for the delectation of the travelers are important items. One trunk line annually sells over its route half a million pounds of candy, nearly twice as many sandwiches, and upward of 500 tons of fruit. This does not include what is sold in the waiting-rooms and restaurants of the stations. Here probably as much more of the sweet things are disposed of to hungry passengers.

A million bottles of soft drinks is the annual bill of one road, or rather the amount that thirsty passengers dispose of while waiting for trains. The restaurants on a large trunk line will use upward of fifty carloads of provisions in the course of a year. But these are distributed so generally and gradually that they never block the line of traffic.

The tendency of the public to eat, drink, and read while traveling is so steadily on the increase that more conveniences are being made to satisfy it in this direction. Traveling libraries have become features of the leading parlor cars, and patrons of the road can read their favorite authors or magazines without expense. The traveling café and dining car are as common to-day as the smoker or baggage. To supply these thousands of cars with all the necessary provisions and articles of diet to suit the most fastidious, the general housekeeper in charge of this department buys in wholesale quantities all along the line. A single railroad system will use upward of 50,000 barrels of flour a year for the dining-car service, 40,000 pairs of poultry, 10,000 quarters of beef, and innumerable tons of fruits, pastry, coffee, and vegetables. To be at the head of such an extensive housekeeping department, a manager must buy economically, and dispose of the surplus and waste profitably. Fruits and vegetables out of season in the North in winter are generally purchased in the South and taken aboard the northbound trains at the most convenient point, and northern fruits and vegetables in summer are likewise shipped south in the same way. Thus all the delicacies of the country are used in and out of season at the lowest minimum of cost.

If we should add to the general housekeeping economics of a railroad the items which pertain more distinctly to the gardening or landscape department, we should find more interesting statistics. Every railroad has its landscape gardening department to-day, and tens of thousands of plants, trees, and shrubs are planted and cultivated every season. One eastern road puts out nearly a million bedding plants every season to decorate the grounds around the stations, and another raises cut flowers so that every office and important station is supplied with fresh-cut flowers every day through the summer season. Ten thousand cut flowers are weekly distributed for table decoration on the dining cars. It costs money to support this department, but the indirect results are apparent in the approval, and increased travel, of patrons.

The care of the linen of a single trunk line is a gigantic task. No hotel or series of hotels offers any comparison. The napkins and table linen for the dining service of one road mount up into the tens of thousands, and the towels and bed linen for the sleepers represent nearly as many more separate articles. The annual wash of the sleeper and dining-car service amounts to an expenditure of $25,000, although it is nearly all done by steam and machinery. To keep up the supply of linen upward of ten thousand separate pieces of linen are purchased annually. On the great transcontinental trunk lines more money is spent on the table and bed linen than on such apparently important articles as car brackets for hats and coats or upholstered cushion seats for passengers. Yet so careful is the system that every napkin, towel, table-cloth, sheet, or pillow case must be accounted for, and not one can be lost without some adequate explanation accompanying the report of its disappearance. Strict business principles prevail throughout the whole department.

PRODUCTION, IMPORTS, AND EXPORTS OF IRON AND STEEL.

IRON and steel exportations from the United States have increased tenfold since 1870, fivefold since 1890, and practically one-third since 1900, while for the first eight months of the current fiscal year they are practically six times as much as importations of like commodities during the same period. Figures just compiled by the Department of Commerce and Labor through its Bureau of Statistics show that exports of iron and steel manufactures increased from 9 million dollars in the eight months ending with February, 1870, to 68 millions in the corresponding months of 1904 and 102 millions in the same months of the present year. Imports of iron and steel manufactures decreased meantime from 21 millions in the eight months ending with February, 1870, to 19 millions in the first eight months of the fiscal year 1904, and 18 millions in the corresponding period of 1906.

It is only within the last ten or twelve years that exports of iron and steel manufactures have exceeded imports of like commodities, this change in the relative position of such imports and exports having been about coincident with the great expansion of pig-iron production since 1890. The production of pig iron in the United States in 1870 was 1,665,179 tons, or little more than the annual average for several preceding years; subsequent to 1870 the annual output fluctuated between 1 million and 4 million tons until 1886, when the total was 5,683,329 tons; in 1890 it was 9,202,703 tons, and in 1905, practically 23 million tons. Thus the growth in domestic production of pig iron in the period from 1870 to 1890 was about 7½ million tons, and in the period from 1890 to 1905, 13¾ millions, the last fifteen years having therefore shown a gain almost double that of the preceding twenty years. The production of steel has also increased rapidly. In 1870 only 68,750 tons of steel were produced in the United States; in 1880 the total had grown to 1¼ million tons; in 1890, 4¼ millions; in 1900, 10 millions; and for 1904, the latest available year, 14 million tons. Meantime the value of the product of the iron and steel industry in the United States, which in 1870 was 207 million dollars, increased to 297 millions in 1880, 479 millions in 1890, and 836 millions in 1900.

The great expansion in domestic production of pig iron and manufactures of iron and steel has tended to diminish the importations of this class of merchandise. In the calendar year 1870 imports of iron and steel manufactures were valued at a little over 37 million dollars. From that date they rapidly increased, reaching, in 1880, 64 million dollars, the highest point ever touched in any calendar year. Since 1880 they have, with trifling exceptions, ranged downward, decreasing from 64 millions in that year to 45 millions in 1890, 20 millions in 1900; then increasing to 41½ millions in 1902, and again receding to 26 millions in 1905, or 11 million dollars less than the importations during the year 1870, and 38 millions less than those of 1880.

Not only has enlarged domestic production of iron and steel manufactures reduced importations of the foreign product, but it has been followed by increased exportations. In the calendar year 1870 our exports of iron and steel aggregated 18 million dollars; in 1880, 16 millions; in 1890, 27 millions; in 1900, 130 millions, and in 1905, 143 millions. The effect of domestic production upon imports and exports is shown by a comparison of the statistics of each of these factors at parallel dates. In 1870, for example, when domestic pig-iron production was less than 2 million tons, iron and steel imports were 37 million dollars in value and exports of like commodities only 18 millions, or about one-half as much as imports. In 1893, when pig-iron production was 7 million tons, exports of iron and steel manufactures first exceeded imports of like products, the former having been in that year a little more and the latter a little less than 30 million dollars. In 1905 when domestic pig-iron production reached the unprecedented total of 23 million tons imports fell to 26 million dollars, while exports rose to 143 millions, the highest point ever touched in any calendar year.

Summarizing the results of the above analysis, pig iron increased in twenty-five years from 4 million tons in 1880 to 23 millions in 1905, exports of iron and steel manufactures grew from 16 million dollars to 143 millions, while imports of similar commodities meantime decreased from 64 millions to 26 millions of dollars. In other words, domestic pig iron production was in 1905 six times as great as a quarter of a century ago, exports of iron and steel manufactures were nine times as great, while imports thereof were less than one-half as great as those of 1880.

In 1880 imports of iron and steel exceeded exports

of like commodities by nearly 48 million dollars; in 1893 the two movements were practically balanced, while in 1905 exports exceeded imports by 117 million dollars.

The principal articles comprising this exportation of 143 million dollars' worth of iron and steel during the last calendar year, stated in the order of their magnitude, were: Miscellaneous machinery, 25 million dollars; builders' hardware, saws and tools, 12½ millions; pipes and fittings, 8 1/3 millions; electrical machinery, 7 2/5 millions; steel rails, 7 1/3 millions; wire, 7 millions; sewing machines, 6½ millions; locomotives, 5 3/5 millions; and typewriters, 5 millions of dollars. Other important items of less than 5 million dollars' value each were: Billets, ingots, and blooms, 4¾ million dollars; structural iron and steel, 4 1/3 millions; sheets and plates, 3 2/5 millions; pumps and pumping machinery, 3 3/4 millions; nails and spikes, 2½ millions; cash registers, 2 1/5 millions; firearms, 1¾ millions; castings, 1 3/5 millions; steel bars or rods, 1½ millions; printing presses, 1½ millions; shoe machinery, 1 2/5 millions; bar iron, 1¼ millions; and stoves, 1 million dollars; these twenty-three classes supplying in 1905 fully 80 per cent of the total exportations of iron and steel.

As to the destination of iron and steel exports, South America and Mexico are the best customers for our steel rails; Canada, the United Kingdom, and Australia take most of our builders' hardware; electrical machinery goes chiefly to Canada, Japan, Mexico, and Great Britain; sewing machines, chiefly to the United Kingdom, Germany, Argentina, Mexico, and Holland; most of our locomotives to Japan; typewriters, chiefly to the United Kingdom and other European countries, while in lesser amounts the various products of iron and steel are sent to practically every known section of the civilized world.

PINACHROMY AND PINATYPE: NEW PROCESSES OF COLOR PHOTOGRAPHY.*

By H. A. METZ.

DR. E. KOENIG, of the Farbwerke, vorm. Meister, Lucius and Brüning, has developed two new processes in color photography which are known respectively as "pinachromy" and "pinatype." They are not only of interest to the student of chemistry and physics, but are a distinct and important advance toward the reproduction of objects in their natural colors.

In pinachromy, three collodion films are successively superimposed and colored by the action of light on certain sensitive chemical preparations with which the films are coated, thus making a true colored photograph. The process has met with considerable success abroad, and is based on the light sensitiveness of the leuco-bases of the organic dyestuffs. While many of these leuco-bases, for instance those of the safranines, are so oxidizable that they cannot be isolated in a free state, there are others, like the leucomalachite green, which can be easily produced, and are comparatively stable. These more permanent leuco-bases, when exposed for some time to light, become strongly colored.

Dr. Koenig examined all the leuco-bases at his command, but found that when exposed to light, either by themselves, or in gelatin coatings, none of them gave results of the desired strength or brilliancy. Subsequently he selected collodion as the support, and thus obtained the desired increase in sensitiveness, the leuco-bases, in the presence of collodion, becoming strongly oxidized after a comparatively short exposure. This increased reaction he attributed to the presence of the nitric acid groups in the nitro-cellulose, and upon further experiment found that, like nitrocellulose, all nitric acid esters would react. The nitrous acid esters, on the contrary, and the isomeric nitro derivatives of the aliphatic and aromatic hydrocarbons proved ineffective. The nitrosamines showed reactions similar to, but weaker than, those of the nitric acid esters. It is of interest that the light sensitiveness of the mixture of nitrocellulose with the leuco-bases is considerably reduced by the presence of urea or of antipyrine. This would seem to point to the fact that the leuco bodies are oxidized by nitrogen oxides, which separate from the collodion. While nitrocellulose is by no means the most effective of such compounds, still greater sensitiveness resulting from the admixture of leuco-bases with the nitric acid esters of glycerol, glucose, or mannitol, it is the most suitable compound, as it acts at the same time as the film and as the support for the picture. The light sensitiveness of the mixture of nitrocellulose and the leuco bodies can be considerably increased by the addition of nitromannitol.

Blue pictures are produced with leucosetocyanine, which is *o*-chlorotetraethyldiaminotriphenylmethane; green with leucomalachite green, or with *m*-nitro- or *m*-aminotetraethyldiaminotriphenylmethane; red with *p*-leuco-aniline, or leuco-rhodamine; violet with hexamethyl-*p*-leucaniline (the leuco-base of Violet 6 B crystals), and yellow with leucofluorescein or leucoflavaniline. The fixing of the picture is effected with dilute organic acids, of which monochloracetic acid is the best; acetic acid or di- or tri-chloracetic acids cannot be used.

The practical application of this process is as follows: A sheet of paper is coated with the blue collodion mixture and exposed under its corresponding negative. When the blue picture appears sufficiently strong, it is fixed in a 10 per cent solution of chloracetic acid, washed, coated with a thin gelatin film, and dried. This gelatin film serves to protect the first collodion coating from dissolving when the second coating is put on. The dry blue picture is then covered with the yellow collodion mixture and exposed under its corresponding negative, care being taken that the pictures register accurately. After exposure it is fixed, washed, and dried, and the yellow picture produced. The final red picture is obtained in a corresponding manner. On account of the complete transparency of these very thin films, and the brilliancy of the colors produced, the prints appear very uniform. The fastness to light of pinachromy pictures is naturally not absolute, but the dyestuffs used are relatively fast. The poorest is the blue, but even this surpasses the "blue prints" (cyanotypes) in fastness. The quantity of the leuco bodies necessary is extremely small; hence pictures composed of the three-color films cost but a trifle more to produce than ordinary gum or pigment prints.

In pinatype, the second process, on the other hand, a single gelatin film is so treated that a succession of paper prints may be obtained from the colored plate as often as desired. This makes pinatype especially adapted to three-color work, and it is now being carefully tested for this purpose. A bichromated gelatin plate is exposed to light under a photographic negative, and the undecomposed bichromate is removed by washing. Pinatype dyes have the property of dyeing the unhardened gelatin very strongly, whereas the hardened portions are either not colored at all or very slightly. If moist paper, coated with specially prepared gelatin, is now brought into intimate contact with the gelatin layer, colored by means of a pinatype dye, in a short time a colored paper picture with all the half-tones is obtained, which appears strongly colored on those parts not affected by light, while the most exposed parts remain white. From this it is evident that in order to obtain a positive picture the bichromated gelatin layer must be exposed under a diapositive. The facility with which enlarged copies can be made is especially important for three-color photography, as the direct production of large-sized plates in three colors offers many technical difficulties. By this process the negatives can be enlarged directly, whereby all the details are much better preserved than when an enlarged negative has to be prepared from the original negative. The print plates for pinatype, which are not sensitive to light, are steeped with the film side uppermost, for three or four minutes, in a sensitizing solution (2 grammes of chromic acid dissolved in 110 cubic centimeters of water) in shaded daylight or lamplight. The solution must not be warmer than 20 deg. C. Any bubbles of air should be removed with the finger or a brush. A great number of plates may be sensitized, one after the other, in the same bath. After the plates have been sensitized, they are well drained and dried in a dark and not too warm place, free from dust. The sensitized plates keep much longer than sensitized pigment paper, and preserve their qualities completely for two or three weeks. The diapositives to be copied are laid in a frame with the film side in contact with the film side of a sensitized print plate. The exposure time for a print plate is about the same as that for collodion paper. Electric arc light is just as good as direct sunlight for copying. After copying, the pictures should be distinctly seen in brown color on a yellow background. The print plate is now washed in running water until all undecomposed chromic acid has been removed. Usually washing is complete in ten minutes. The plates may now be dried or placed directly in the dye solution. The well-washed print plate, either dry or moist, which corresponds to the red filter negative, is steeped in the blue dye solution composed of 5 grammes of "pinatype blue" dissolved in 250 cubic centimeters of water, and the dish rocked from time to time. The first dyeing takes about 15 minutes. The plate is then washed and rinsed until the water running off from it is no longer colored. It should have the appearance of the diapositive full of detail, with almost transparent whites and intense shades. When the dyed plate is finished, a piece of transfer paper of the size of the plate is softened in cold water, all air bubbles being removed, until the paper has become completely pliable and fully stretched. The paper is now attached to the plate, preferably under water, with the film side against the film side of the printed plate, and both removed from the bath, at the same time draining off the excess of water by a gentle motion of the hand. The plate is then laid upon a table, paper uppermost, and protected with a piece of oiled silk or the like, and the paper firmly smoothed over with a rubber squeegee, from the middle outward, using moderate pressure. The operation is similar to that in the pigment process. When the paper adheres satisfactorily it is covered with a damp sheet and a glass plate, in order to prevent evaporation, and the whole allowed to stand 10 to 15 minutes, if desired, under a light weight. At the end of this time the picture will be found transferred to the paper with sufficient strength. The paper is now removed and hung up to dry. The print plate is now again placed for about five minutes in the dyebath, rinsed, and the picture again transferred to paper as above directed. These operations may be repeated as often as desired. By repeated immersion in the dyebath the print plate becomes darker. Nevertheless, the prints from the plate are quite uniform, as only the exterior surface of the dyed plate has action on the paper. The dyed plates may be kept for any length of time after use, and can be again employed after a fresh immersion in the dyebath. The dyeing of the print plate corresponding with the green filter negative is done in the same manner. For the dye-bath 5 grammes of "pinatype red" are stirred with a little water to a paste, and then 3 to 5 cubic centimeters of concentrated ammonia solution added. Sufficient ammonia must be used to completely dissolve the dye to a clear deep red solution. After about five minutes the solution is diluted with cold water to 250 cubic centimeters. After the red plate has been washed free from the excess of dyestuff, the blue picture is softened in water and laid under water upon the red print plate. The operation is carried out in the same way as before described, the blue picture being easily shifted under water, so as to exactly correspond to the red print plate. When the adjustment is complete, the paper is held firmly against the plate with suitable clamps, leaving the film free. The film is then withdrawn, water again run over the plate, and the paper pressed firmly down with the squeegee. It is allowed to stand for 10 to 15 minutes, and the paper then removed from the plate. About 30 minutes should be allowed for the first immersion of the print plate, corresponding to the blue filter negative, in a dyebath composed of 5 grammes of "pinatype yellow" dissolved in 200 cubic centimeters of hot water; for subsequent immersions, five to ten minutes. The yellow transfer upon the blue and red picture takes about 30 minutes. It is advisable to moisten the superimposed damp sheet well in order to prevent the films adhering to each other. To increase the picture's fastness to light, and to harden the gelatin layer, the paper is now immersed for about one to two minutes in a fixing bath of 2 grammes of fixative chromium salt and 100 cubic centimeters of water. After fixing, the picture is washed for about five minutes in clean water and hung up to dry.

The principal advantages of pinatype lies in the use of print plates, which are prepared in a simple manner with the aid of light, allowing the preparation of a large number of paper copies therefrom by a purely mechanical process, without further recourse to light. The print plates can be kept and used again at any time, without the aid of light, for the preparation of paper copies. In consequence of the intensity of the pinatype dyestuffs and the immunity from spoiled pictures, pinatypes are very cheap. Pinatypes are extremely fast to light. A three-colored pinatype is not composed of different films. A single thin film carries all of the colors, which therefore blend harmoniously.

* Journal of Society of Chemical Industry.

OZOBROME PHOTOGRAPHY.

By CHAPMAN JONES, F.I.C., F.C.S., Etc.

THIS curious word is derived from "ozone" and "bromine," though it indicates a process with which ozone has nothing to do, and bromine very little. It is a method recently patented by Mr. Thomas Manly (who, a few years ago, introduced the ozotype process), by which a bromide print is made to furnish one or several carbon prints. This means that the facility of making a bromide print either by contact or enlarging methods, necessitating only a few seconds' exposure to artificial light, may be combined with the advantages of carbon or pigment prints with their permanency and the wide choice of colors that they permit. Indeed, the new method presents notable advantages as compared with the ordinary carbon process, for not only is daylight unnecessary for the exposure, but the print is not laterally reversed though there is no double transfer, and in one modification no transfer at all. The principles involved are very simple. The bromide print consists of a metallic silver image in a gelatin film. Silver is in many cases a very efficient reducer, and by bringing into contact with it a pigmented gelatin film sensitized with a bichromate, the silver, directly or indirectly, reduces the chromate, much as exposure to light would, to a chromium compound which renders the gelatin insoluble.

The practical details run on the following lines: A bromide print, which may be an old one, but must have been thoroughly washed, is soaked in a formaline solution for a few minutes to harden the gelatin, and washed. The carbon tissue or "pigment plaster" that is to be used is soaked till limp in a solution that contains an alkaline bichromate, ferricyanide, and bromide, while the bromide print is soaked in water, and the two squeegeed together. If one print only is required, after a few minutes the print is plunged into hot water and developed in the same manner as a single transfer carbon print. But if desired, the same bromide print will furnish several carbon prints, by plunging the original with the carbon tissue squeegeed to it into cold water, separating them gently, and then treating the carbon tissue exactly as if it had been just exposed to light in ordinary carbon printing. The short contact with the original is equivalent to the otherwise necessary, and often prolonged, exposure to daylight under the negative. The silver of the bromide print is changed into a silver salt, but immersion in an ordinary developing solution reduces it to the metallic state, and so it can be used over and over again. It seems that all carbon tissue is not suitable, and that a specially soluble kind is supplied by the patentee. Full working details will probably be obtainable before this is published, together with modifications and other applications of the process.

This process seems, on the face of it, to have so much to commend it that the essential difference between it and carbon printing by the ordinary methods must not be lost sight of. Carbon printing, as hitherto practised, is a printing-out process, and the charm of a carbon transparency, as well as its reliability for reproduction purposes, lies largely in this fact. Probably no method gives a more exact representation of the negative, for the possibilities of altering the gradation by accident or design are hardly worth consideration. But in the "ozobrome" methods, the result depends upon development in the same sense in which

the negative is developed, and while this may sometimes be an advantage to the skilled worker, it renders all sorts of errors possible. This radical difference must ever be borne in mind.—Knowledge and Scientific News.

LIGHTS OF OTHER DAYS.*

By FRED R. COLES.

I.—CANDLESTICKS.

IN pursuing our inquiry into the condition of homely life when such light-givers as the peerman were in vogue, we are met by a group of peculiar implements which certainly were the very reverse of anything akin

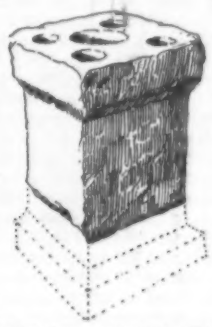


FIG. 1.—TAILOR'S CANDLESTICK FROM DALKEITH.

to the Will o' the Wisps of that bygone epoch. A good deal of "glimmering" or "gloaming" might be, and no doubt was, tolerated during the long "forenichts" of winter in the farm-houses; but to the busy village tradesman a clear, constant and equable light was required. Without it what became of the weaver, the bootmaker, the tailor? To the last named, indeed, such a provision of light was an absolute *sine qua non;* fancy stitching at a dark suit in the glimmer of a flaring torch! "Johnnie Gibb" knew better, so he provided himself with a sturdy, plain, solid support for holding several candles at once, and placed between them a large round hollow into which the trimmings of his well-snuffed wick were dropped, from time to time, as the flame waned and the smoke warned him to brighten the light. Why these tailors' candlesticks

FIG. 2A.—TAILOR'S CANDLESTICK IN FORM OF ROMAN ALTAR.

took the form of Roman altars is a problem we may touch later on; when they did so may be approximately ascertained by noting the dates incised along with their owners' names, though the earliest known specimens so dated may, of course, not represent the earliest candlestick of this type in use.†

In the Scottish National Collection there are several examples of these tailors' candlesticks. They are all of stone, and mostly carved out in direct and almost complete resemblance to the typical Roman altar. Our first illustration (Fig. 1) shows a plain, heavy, and broken specimen, which was found built into the wall of a house at Dalkeith. In its present condition, lacking the base, it stands 10 inches in height, and is 8 inches square at the top. It has four candle-sockets and a large central saucer-shaped snuff-holder. This severely utilitarian implement, devoid of the least line of decoration or of any representation of the "shears"

FIG. 2B.—TAILOR'S CANDLESTICK IN FORM OF ROMAN ALTAR.

or the "goose" belonging to the tradesman's outfit, uninitialed and undated, could surely never have been put to any graceful use, or helped to shed light upon the trappings of any rustic Beau Brummel—there is such a journeyman look about its uncouth contours, a hard every-day common-placeness. How different from the next specimen—a really neatly carved and well-proportioned altar (Fig. 2), which possesses all that the first lacks; evidence of proprietorship first of all, and of the honorable pride this man (whose initials were I. A.) took in his craft and its belongings. The date is 1634, possibly the earliest dated specimen known. The next drawing shows a specially interesting candlestick (Fig. 3). It has an octagonal top, and in most other respects bears a close resemblance to the last specimen; but it is larger, and, in addition to the symbols of the craft, the owner's name—Andro Lesels—with the initials repeated on a separate face. Its fourth side is particularly conspicuous by reason of a neat shield with coat of arms carved in strong relief. This shield itself is of interest, it has a double tressure and eight *fleur-de-lis*, and, above two

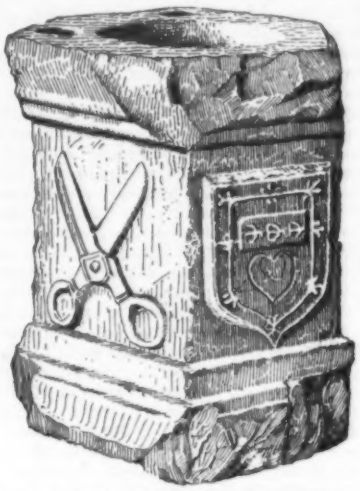


FIG. 3.—TAILOR'S CANDLESTICK.

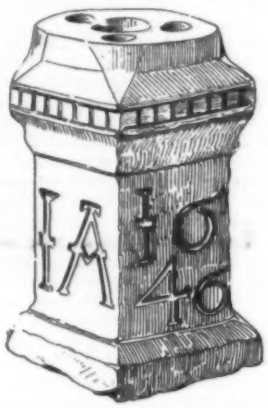


FIG. 4A.—TAILOR'S CANDLESTICK.

hearts, one of which is faintly incised within the other, in an oblong bearing three buckles. On first thoughts the idea that Lesels was a corrupted form of Lascelles occurred, with the assumption that this coat of arms belonged to that French family. On consulting the Lord Lyon King of Arms, however, it was made clear that the coat rather suggested that of Leslie, which has a bend and three buckles, and possibly the spelling, Lesels, was a variant of Leslie. However this may be, the shield serves to specialize this candlestick.

In the example that follows (Fig. 4), though the general resemblance is maintained, we notice only

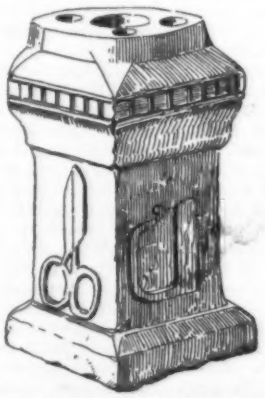


FIG. 4B.—TAILOR'S CANDLESTICK.

three sockets round the snuff-holder. Curiously enough, the initials I. A. are incised on this candlestick also, and with the date 1646, a dozen years later than that affixed to the candlestick above noticed with the same initials. There is no record showing the source from which the earlier candlestick was obtained, but the original of Fig. 4 is in the museum at Perth. A fifth example is but a fragment of the upper portion of the Roman altar, and only differs from the others in having the snuff-holder deeply cut out in the shape of a heart. The last specimen here shown (Fig. 5) is a departure from the typical form. Instead of the square top and molded edges, this candlestick is cut out of a squarish block of stone in two tiers, with a couple of sockets on each, and a slight hollow, presumably as the snuff-holder, between the two upper sockets. Moreover, it posesses two pairs of "shears" and two specimens of the "goose." One might conjecture all this implied a partnership in business, and, if so, in lights, were it not for the simple R. B. incised on the face of the upper tier. This specimen was acquired with the Sturrock Collection.

An uncommon form of stone candlestick, barely to be called picturesque, is composed of four thick pillars built round a wide oblong-shaped snuff-holder. It

FIG. 5A.—TAILOR'S CANDLESTICK.

stands 8½ inches in height, and is 6½ inches in full width, and it is heavy enough to have been used in the same way and subjected to the same unkind treatment as most of the Roman altar specimens appear to have been.

Metal candlesticks introduce us to a metal probably very little known—this is *latten*. This substance is described, under its French appellative *laiton*, as copper made yellow by the admixture of a little calamine; and, on pressing our inquiry, we find calamine described as the *lapis calaminaris* or *cadmia nativa*, which

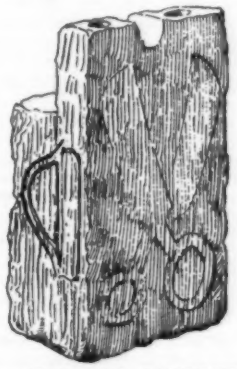


FIG. 5B.—TAILOR'S CANDLESTICK.

is said to be the crust formed in zinc furnaces containing ten to twenty per cent of cadmium, which is a roundabout way of stating that latten is a kind of brass. One authority, indeed, describes latten* outright as sheet-brass, adding the note, which is of some archæological interest, that during the reign of Henry VIII. frequent mention is made of "mines of latten" in various public records, without explanations of its nature. This candlestick of latten is from Wigtownshire, being one of the many donations to the National Museum made by the present president of the Society of Antiquarians of Scotland, the Rt. Hon. Sir H. E. Maxwell, of Monreith. My drawing of it (Fig. 6) was purposely made as viewed from above in order to bring

FIG. 6.—TOP OF CANDLESTICK OF LATTEN FROM WIGTOWNSHIRE.

well out the very neat socket and branching fork on either side, the shaping of which is unusually skillful and finished with much care. In the circular tripod base these same qualities are also apparent. The candlestick stands 7¾ inches in height, and measures across the feet 4 inches.

The use of wood as a material for candlesticks does not seem consonant with the cautiousness of thrifty folk—Scots or English, yet such do exist. Our next illustration (Fig. 7) consists of a round, flat base, a fluted pillar and upper portion of stem entirely of polished dark red wood, surmounted by a fairly wide

* The Reliquary and Illustrated Archæologist.

† In an important and very suggestive article on "The Archæology of Lighting Appliances," by Mr. J. Romilly Allen, in the Proc. Soc. Ant., Scot., vol. xxii., p. 84, reference is made to a paper by Rev. J. Lees, read before the British Archæological Institute, describing certain "Creaset Stones" which bear some resemblance to the Roman altar candlestick.

* See under "Latten," Chambers's Encyclopædia.

sconce of brass scalloped along the edge. One need scarcely marvel that the wood just beneath the brass mounting has split with use. This candlestick belonged to Lady Lovat,* a name which swiftly recalls memories of pathetic interest enough of the ill-used and ill-fated Lady Grange.†

With an illustration of the rather quaint wooden candlestick (Fig. 8) from Inverkeithing, this notice of candlesticks may close. It is made of alderwood, lathe-turned, and stained and polished, and consists of a solid carrot-form body into which are slotted the four thin leg-pieces terminating in horses' heads. There is no metal in this candlestick, nor is its slender build and the comparatively narrow "tread" of its supports at all conducive to safety. It stands about 10 inches in height.

FIG. 7.—CANDLESTICK OF WOOD WITH BRASS SCONCE.

II.—LANTERNS OF WOOD AND TIN.

Hitherto we have mainly been considering the implements and appliances constructed for the diffusion of light more or less fixed and confined to indoor purposes. In studying some of the implements next in order, we shall try to ascertain how far toward usefulness some of the portable contrivances attained, or how far short of the ideal they fall.

Take, for example, this substantial and cleverly-made lantern‡ (Fig. 9) of wood and horn, a striking example of homely ingenuity and in its way a very picturesque object. The bottom, sides, and gable-shaped top are of wood, so stained and scarred and with edges so rounded and polished by use that one cannot with any certainty say what the wood is. Onto the bottom, which is 5 inches square, there are nailed three side pieces, measuring at the apex 10½ inches in height and 4½ inches in width, the top being formed of two sloping pieces 4½ inches in length by 2½ inches in width. These top pieces do not meet, except at the extreme outer angles, for a wide, irregularly-scooped hollow has been made there to act as a smoke vent. They are nailed to the uprights; whether the nailing became insecure or not the sides are, in addition, bound, both vertically and horizontally, by strong tarred cords knotted at the angles. The cords are fastened in a twisted loop round a flat-headed nail, which also helps to hold firmly down a broad strap of leather to the foot of the side behind the door; this leather is now so hard and tough as to be with difficulty distinguished from iron. The sides or windows within this framework of wood are of horn, well secured in their places by putty. The door is of wood half an inch in thickness, hinged with stout flexible leather fastened with seventeen rivet-headed nails on the outside, the three edges of the door being turned over with leather similarly fastened.

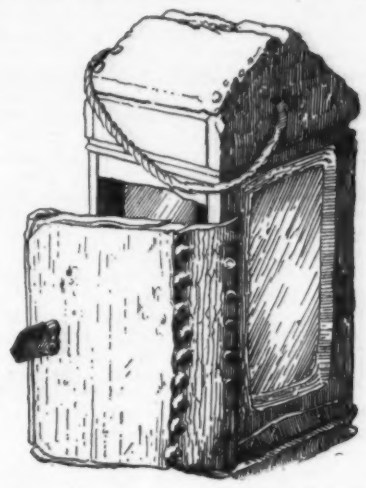


FIG. 9.—LANTERN OF WOOD AND HORN FROM ABERDEENSHIRE.

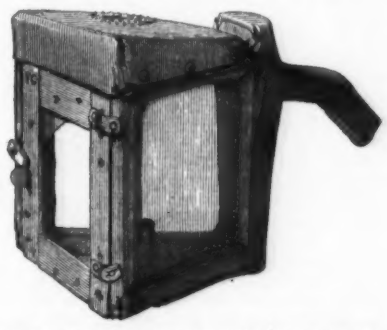


FIG. 10.—LADY GRIZEL BAILLIE'S LANTERN.

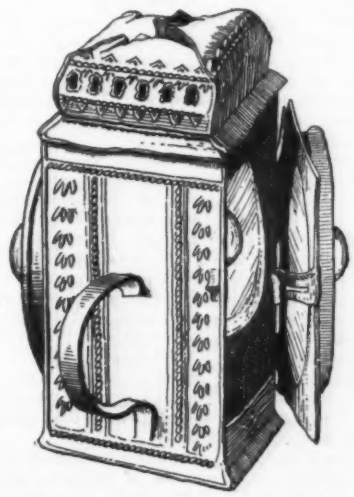


FIG. 11.—"BULL'S-EYE" LANTERN OF TIN.

The floor of the lantern is pierced by a rudely circular candle hole, and the lantern is carried by a short, thick cord run through the "gables" and knotted within.

Though devoid of written record, this sturdy old homely lantern, with its unmistakable signs of rough and frequent use and its stout lineaments well adapted for such use, is in its own way an epitome of the self-dependence and ingenuity of the maker who fashioned it with the simple tools and simpler materials at hand, scorning to procure a costlier and more showy article. Likely as not, he lived far away from all shops!

About our next specimen (Fig. 10) both incident and romance have cast a glamour of pathetic and personal interest, for this curious, simple, three-cornered lantern was carried by Lady Grizel Baillie on her nightly visits to her father, Sir Patrick Hume, during his concealment in the vault beneath Polwarth Church, in 1684. It was through the good offices of the Misses Warrender that this unique specimen found its resting place in the National Museum.*

FIG. 12.—GLASGOW APPRENTICE'S LANTERN.

A close comparison with the preceding specimen shows that in three respects only is this lantern an improvement upon that; its sides are of glass, it has a tin candle-socket, and the broad, triangular top is of tin perforated with a large, round smoke-hole surrounded by numerous small holes, otherwise its features are of a truth plebeian enough! Note the handle and back, simply the curved branch and vertically cut stem of an ash-tree, polished only by much handling; the wooden framework of the windows, each of two common thinnish pieces of wood, clamped together by the simple process of hammering down the points of the nails when driven through; the bottom, of two still thinner and now very much worm-eaten pieces, held to the uprights by four clumsy nails; the tin cap, not even cut to fit exactly, fastened to the top-piece with equally clumsy nails; and the slight (one would think barely sufficient) leathern straps which form the hinges of the door.

FIG. 13.—CANDLE-HOLDER IN GLASGOW APPRENTICE'S LANTERN.

And yet the lantern is as firm and solid as possible, and, were it reglazed, would be as serviceable to-day as when, more than two hundred years ago, devoted Lady Grizel held it in her dainty hand.

FIG. 14.—LANTERN OF IRON AND GLASS.

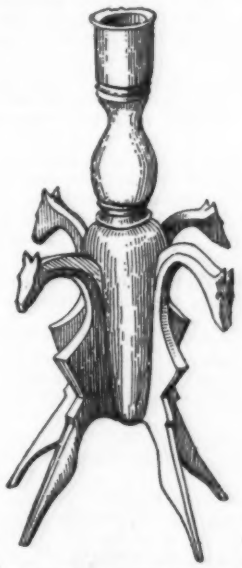


FIG. 8.—WOODEN CANDLESTICK FROM INVERKEITHING.

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* The wife of "Simon Fraser of Beaufort, better known to infamy as Lord Lovat." (Hill Burton, "Hist. Scot.", vol. i., p. 178.) He was the originator of the Queensberry Plot in 1703, took an active share in the Rebellions of 1715 and 1745, and in the following year "was sent to his last account laden with an almost unexampled heap of crimes." (Ibid, vol. ii., p. 530.)

† The wife of James Erskine, of Grange, a brother of the Earl of Mar. He was on the Scottish Bench between 1707 and 1734, secretly a Jacobite, a born intriguer and an accomplished hypocrite. In 1732, Lady Grange, partially insane, was, by her husband's orders, kidnapped, and conveyed through Glencoe to Loch Hourn, thence to the Isle of Hasker, near Skye, and finally to St. Kilda. *Vide* J. Hill Burton's "Hist. Scot.", vol. ii., p. 304, and for some further light on this dark page of family history, papers by David Laing, in Proc. Soc. Antiq. Scot., vol. x., p. 722, vol. xi., p. 595, and vol. xii., p. 312, the last containing a copy of the original letter of Separation, etc., from Rachael Chiesly, to James Erskine of Grange.

‡ We may note in passing that the New English Dictionary records no fewer than eighteen varieties in the spelling of this word; and adds, "that the form 'lanthorn' is probably due to popular etymology, lanterns having formerly been almost always made of horn." Friar's Lantern was an old rustic name for *ignis fatuus*, will o' the wisp.

* Sir P. Hume was suspected of being concerned in the Ryehouse Plot, and only saved his life by concealing himself in the vault beneath Polwarth Church. His eldest daughter, Grizel, then only 18, lived with her mother at Redbraes, about one mile off. She brought her father food and drink every night for a month, crossing the churchyard to do so, and hastening home at the first glimmerings of dawn. "For fear of exciting the suspicions of the servants, she had to convey part of her own dinner off her plate into her lap, in order to secure food for her father; and it was on one of these occasions that her little brother Sandy (afterwards the second Lord Marchmont), turned to Lady Polwarth in consternation, and complained: 'Mother, will ye look at Grisel; while we have been eating our broth, she has eaten up the whole sheep's head!'" ("Marchmont, and the Homes of Polwarth," by Margaret Warrender, p. 31.)

Our next specimen (Fig. 11) is entirely of tin and glass, smaller than the lantern just noticed, being only 5½ inches in height, with definite decoration and a "bull's-eye" in each of its three windows. The style of its ornament is so obvious as to call for no comment. There is a small candle-socket, and attached to the back of the inside of the lantern is a narrow vertical strip of tin just over 2 inches long, having its upper end free. Unless this were a contrivance for suspending a small reflector by—as in quite modern toy magic-lanterns—it is not easy to account for. The thin metal base of this lantern is kept from direct contact with any surface liable to be damaged by heat by four small strips of tin soldered at the angles and bent round so as to form a kind of foot.

Folding pocket-lanterns of thin metal, hinged something on the same principle as the up-to-date sandwich case, would seem to have been in common use not so very long ago. The specimen here illustrated (Fig. 12) belongs to the class known as Glasgow Apprentice Lanterns, and was once in the Sim Collection. It is of tin, 6¾ inches in height and 3¼ inches in width; its sides are of horn held in place by an edging of tin soldered on the inside; the top is of open work, as are also the curved tops of the sides and their straight bases. Small brass hooks pivoted on a flat-headed stud fasten the sides. When open, the lantern is 3⅝ inches wide and thick, when closed ¾ inch thick. On the bottom is a clever contrivance for adapting the candle-hole to the size of the candle (see Fig. 13). It consists of three parts: *P*, the pivot upon which *A*, the sneck, turns, and slides below the bar, *B*, in such a manner that by pushing the little rolled end of tin, *C*, upward we can alter its position to that of the dotted lines, and thereby diminish the candle-hole from a circle ¾ of an inch in diameter to an ellipse of less than half that space.

A better finished and more "natty" specimen was bought recently at Dundee, and shown to me by Mr. D. Falconer.

An unusually large heavy tin lantern, with a conical top, now in the museum, hails from Aberdeenshire. It possesses few of the attributes of quaintness or picturesqueness exhibited by most of the examples here described, except for the fact of its "light-holes," which are protuberant, being fitted with a curiously varied set of glasses, some of them star-shaped—one has a scalloped edge. The vertical height of this cylindrical lantern is 9¼ inches, but including the conical top, 13 inches; the diameter of its base is 6½ inches. The top has a short chimney, and is also perforated with small holes in a pattern of rings. Externally attached to one part, just below the rim of the top-piece, is a projecting ring of metal half an inch deep, and directly below it, attached to the base, a second such ring, a contrivance by which the lantern could be suspended to some part of a cart, probably, or to an upright staple in an outhouse.

I bring these notes to a conclusion with a drawing of what seems a very uncommon form of lantern (Fig. 14). It is horseshoe-shaped, and of iron and glass; it stands only 4 inches in height, is 3½ inches wide, and nearly 2 inches deep. Into the upper part is fitted a movable chimney with long neatly-cut holes; this can be pushed down so as to lie flush with the top, or can be raised as shown in the illustration. There is a socket for a single piece of tin left unjointed at the edges. The door is provided in the middle of the outside with a strap of tin, soldered at the upper end in such a way that its lower end could be pushed into a crevice or small iron loop, and on either side of this "hook" is a handle formed of two pieces of wire rod one-eighth of an inch thick, which can turn back flat against the door, or be turned out projectingly as shown. The fastener is gone. The use of the wire rod, which appears to be the same as that of which wire fencing is made, proves that this odd little lantern cannot lay claim to a high antiquity; but its very homeliness of construction renders it an object of some interest, and it, along with flint, steels, tinder-box, rush-light, wooden spunks, will, ere long—who knows?—share in the attention of future antiquarians, who will look back upon an early box of Bryant & May's matches or a pocket vesta-box with the same respect as we do upon these various forms of the Lights of Other Days.

[Continued from SUPPLEMENT No. 1589, page 25615.]

THE INCREASE OF KNOWLEDGE IN THE SEVERAL BRANCHES OF SCIENCE.*

By PROF. E. RAY LANKESTER, M.A., LL.D., D.Sc., F.R.S., F.L.S.

IT must be obvious from all the foregoing that radium is very slowly, but none the less surely, destroying itself. There is a definite loss of particles which, in the course of time, must lead to the destruction of the radium, and it would seem that the large new credit on the bank of time given to biologists in consequence of its discovery has a definite, if remote, limit. With the quantities of radium at present available for experiment, the amount of loss of particles is so small, and the rate so slow, that it cannot be weighed by the most delicate balance. Nevertheless it has been calculated that radium will transform half of itself in about fifteen hundred years, and unless it were being produced in some way all of the radium now in existence would disappear much too soon to make it an important geological factor in the maintenance of the earth's temperature. As a reply to this depreciatory statement we have the discovery by Rutherford and others that radium is continually being formed afresh, and from that particular element in connection with which it was discovered—namely, uranium. Hypotheses and experiments as to the details of this process are at this moment in full swing, and results of a momentous kind, involving the building up of an element with high atomic weight by the interaction of elements with a lower atomic weight, are thought by some physicists to be not improbable in the immediate future.

The delicate electric test for radio-activity has been largely applied in the last few years to all sorts and conditions of matter. As a result it appears that the radium emanation is always present in our atmosphere; that the air in caves is especially rich in it, as are underground waters. Tin foil, glass, silver, zinc, lead, copper, platinum, and aluminium are, all of them, slightly radio-active. The question has been raised whether this widespread radio-activity is due to the wide dissemination of infinitesimal quantities of strong radio-active elements, or whether it is the natural intrinsic property of all matter to emit Becquerel rays. This is the immediate subject of research.

Over and above the more simply appreciable facts which I have thus narrated, there comes the necessary and difficult inquiry, What does it all mean? What *are* the Becquerel rays of radio-activity? What must we conceive to be the structure and mechanism of the atoms of radium and allied elements, which can not only pour forth ceaseless streams of intrinsic energy from their own isolated substance, but are perpetually, though in infinitesimal proportions, changing their elemental nature spontaneously, so as to give rise to other atoms which we recognize as other elements?

I cannot venture as an expositor into this field. It belongs to that wonderful group of men, the modern physicists, who with an almost weird power of visual imagination combine the great instrument of exact statement and mental manipulation called mathematics, and possess an ingenuity and delicacy in appropriate experiment which must fill all who even partially follow their triumphant handling of nature with reverence and admiration. Such men now or recently among us are Kelvin, Clark, Maxwell, Crookes, Rayleigh, and J. J. Thomson.

Becquerel showed early in his study of the rays emitted by radium that some of them could be bent out of their straight path by making them pass between the poles of a powerful electro-magnet. In this way have finally been distinguished three classes of rays given off by radium: (1) the *alpha* rays, which are only slightly bent, and have little penetrative power; (2) the *beta* rays, easily bent in a direction opposite to that in which the alpha rays bend, and of considerable penetrative power; (3) the *gamma* rays, which are absolutely unbendable by the strongest magnetic force, and have an extraordinary penetrative power, producing a photographic effect through a foot thickness of solid iron.

The alpha rays are shown to be streams of tiny bodies positively electrified, such as are given off by gas flames and red-hot metals. The particles have about twice the mass of a hydrogen atom, and they fly off with a velocity of 20,000 miles a second; that is, 40,000 times greater than that of a rifle bullet. The heat produced by radium is ascribed to the impact of these particles of the alpha rays.

The beta rays are streams of corpuscles similar to those given off by the cathode in a vacuum tube. They are charged with negative electricity and travel at the velocity of 100,000 miles a second. They are far more minute than the alpha particles. Their mass is equal to the one-thousandth of a hydrogen atom. They produce the major part of the photographic and phosphorescent effects of the radium rays.

The gamma rays are apparently the same, or nearly the same, thing as the X-rays of Röntgen. They are probably not particles at all, but pulses or waves in the ether set up during the ejection of the corpuscles which constitute the beta rays. They produce the same effects in a much smaller degree as do the beta rays, but are more penetrating.

The kind of conceptions to which these and like discoveries have led the modern physicist in regard to the character of that supposed unbreakable body—the chemical atom—the simple and unaffected friend of our youth—are truly astounding. But I would have you notice that they are not destructive of our previous conceptions, but rather elaborations and developments of the simpler views, introducing the notion of structure and mechanism, agitated and whirling with tremendous force, into what we formerly conceived of as homogeneous or simply built-up particles, the earlier conception being not so much a positive assertion of simplicity as a non-committal expectant formula awaiting the progress of knowledge and the revelations which are now in our hands.

As I have already said, the attempt to show in detail how the marvelous properties of radium and radio-activity in general are thus capable of a pictorial or structural representation is beyond the limits both of my powers and the time allowed me; but the fact that such speculations furnish a scheme into which the observed phenomena can be fitted is what we may take on the authority of the physicists and chemists of our day.

Intimately connected with all the work which has been done in the past twenty-five years in the nature and possible transformations of atoms is the great series of investigations and speculations on astral chemistry and the development of the chemical elements which we owe to the unremitting labor during this period of Sir Norman Lockyer.

Wireless Telegraphy.—Of great importance has been the whole progress in the theory and practical handling of electrical phenomena of late years. The discovery of the Hertzian waves and their application to wireless telegraphy is a feature of this period, though I may remind some of those who have been impressed by these discoveries that the mere fact of electrical action at a distance is that which hundreds of years ago gave to electricity its name. The power which we have gained of making an instrument oscillate in accordance with a predetermined code of signaling, although detached and a thousand miles distant, does not really lend any new support to the notion that the old-time beliefs of thought-transference and second sight are more than illusions based on incomplete observation and imperfect reasoning. For the important factors in such human intercourse—namely, a signaling-instrument and a code of signals—have not been discovered, as yet, in the structure of the human body, and have to be consciously devised and manufactured by man in the only examples of thought-transference over long distances at present discovered or laid bare to experiment and observation.

High and Low Temperatures.—The past quarter of a century has witnessed a great development and application of the methods of producing both very low and very high temperatures. Sir James Dewar, by improved apparatus, has produced liquid hydrogen and a fall of temperature probably reaching to the absolute zero. A number of applications of extremely low temperatures to research in various directions has been rendered possible by the facility with which they may now be produced. Similarly high temperatures have been employed in continuation of the earlier work of Deville, and others by Moissan, the distinguished French chemist.

Progress in Chemistry.—In chemistry generally the theoretical tendency guiding a great deal of work has been the completion and verification of the "periodic law" of Mendeljeff; and, on the other hand, the search by physical agents such as light and electricity for evidence as to the arrangement of atoms in the molecules of the most diverse chemical compounds. The study of "valency" and its outcome, stereo-chemistry, have been the special lines in which chemistry has advanced. As a matter of course hundreds, if not thousands, of new chemical bodies have been produced in the laboratory of greater or less theoretical interest. The discovery of the greatest practical and industrial importance in this connection is the production of indigo by synthetical processes, first by laboratory and then by factory methods, so as to compete successfully with the natural product. Von Baeyer and Heumann are the names associated with this remarkable achievement, which has necessarily dislocated a large industry which derived its raw material from British India.

Astronomy.—A biologist may well refuse to offer any remarks on his own authority in regard to this earliest and grandest of all the sciences. I will therefore at once say that my friend the Savilian Professor of Astronomy in Oxford has turned my thoughts in the right direction in regard to this subject. There is no doubt that there has been an immense "revival" in astronomy since 1881; it has developed in every direction. The invention of the "dry plate," which has made it possible to apply photography freely in all astronomical work, is the chief cause of its great expansion. Photography was applied to astronomical work before 1881, but only with difficulty and haltingly. It was the dry-plate which made long exposures possible, and thus enabled astronomers to obtain regular records of faintly luminous objects such as nebulæ and star-spectra. Roughly speaking, the number of stars visible to the naked eye may be stated as eight thousand; this is raised by the use of our best telescopes to a hundred million. But the number which can be photographed is indefinite and depends on length of exposure; a thousand million can certainly be so recorded.

The serious practical proposal to "chart the sky" by means of photography certainly dates from this side of 1881. The Paris Conference of 1887, which made an international scheme for sharing the sky among eighteen observatories (still busy with the work, and producing excellent results), originated with photographs of the comet of 1882, taken at the Cape Observatory.

Prof. Pickering, of Harvard, did not join this co-operative scheme, but has gradually devised methods of charting the sky very rapidly, so that he has at Harvard records of the whole sky many times over, and when new objects are discovered he can trace their history *backward* for more than a dozen years by reference to his plates. This is a wonderful new method, a mode of keeping record of present movements and changes which promises much for the future of astronomy. By the photographic method hundreds of new variable stars and other interesting objects have been discovered. New planets have been detected by the hundred. Up to 1881 two hundred and twenty were known. In 1881 only one was found; namely, Stephania, being No. 220, discovered on May 19. Now a score at least are discovered every year. Over five hundred are now known. One of these (Eros, No. 433) is particularly interesting, since it is nearer to the sun than is Mars, and gives a splendid opportunity for fixing with increased accuracy the sun's distance from the earth. Two new satellites to Saturn and two to Jupiter have been discovered by photography (besides one to Jupiter in 1892 by the visual telescope of the Lick Observatory). One of the new satellites of Saturn goes round that planet the *wrong way*, thus calling for a fundamental revision of our ideas of the origin of the solar system.

The introduction of photography has made an im-

* Presidential address delivered to the British Association for the Advancement of Science.

mense difference in spectroscopic work. The spectra of the stars have been readily mapped out and classified, and now the motions in the line of sight of faint stars can be determined. This "motion in the line of sight," which was discernible but scarcely measureable with accuracy before, now provides one of the most refined methods in astronomy for ascertaining the dimensions and motions of the universe. It gives us velocities in miles per second instead of in an angular unit to be interpreted by a very imperfect knowledge of the star's distance. The method was in 1881 a mere curiosity, which Huggins was almost alone in having examined, though visual measures had been begun at Greenwich in 1875, and were continued for many years, only to be ultimately found to be affected by systematic error. The photographic method started by Vogel in 1887 really has made all the difference, and this work is now a vast department of astronomical industry. Among other by-products of the method are the "spectroscopic doubles," stars which we know to be double, and of which we can determine the period of revolution, though we cannot separate them visually by the greatest telescope.

Work on the sun has been entirely revolutionized by the use of photography. The last decade has seen the invention of the spectro-heliograph—which simply means that astronomers can now study *in detail* portions of the sun of which they could previously only get a bare indication.

More of the same story could be related, but enough has been said to show how full of life and progress is this most ancient and imposing of all sciences.

A minor though very important influence in the progress of astronomy has been the provision, by the expenditure of great wealth in America, of great telescopes and equipments.

In 1877 my distinguished predecessor in the presidency of the British Association started a line of mathematical research which has been very fruitful and is of great future promise for astronomy. He was able himself last year to give some account of this research to the association. On the present occasion I may mention that as recently as last April, at the Royal Astronomical Society, two important papers were read—one by Mr. Cowell and the other by Mr. Stratton—which have their roots in Sir George Darwin's work. The former was led to suggest that the day is lengthening ten times as rapidly as had been supposed, and the latter showed that in all probability the planets had all turned upside down since their birth.

And yet M. Brunettière and his friends wish us to believe that science is bankrupt and has no new things in store for humanity.

Geology.—In the field of geological research the main feature in the past twenty-five years has been the increasing acceptance of the evolutionary as contrasted with the uniformitarian view of geological phenomena. The great work of Suess, "Das Antlitz der Erde," is undoubtedly the most important contribution to physical geology within the period. The first volume appeared in 1885, and the impetus which it has given to the science may be judged of by the epithet applied to the views for which Suess is responsible—"the New Geology." Suess attempts to trace the orderly sequence of the principal changes in the earth's crust since it first began to form. He strongly opposes the old theory of elevation, and accounts for the movements as due to differential collapse of the crust, accompanied by folding due to tangential stress. Among special results gained by geologists in the period we survey may be cited new views as to the origin of the crystalline schists, favoring a return to something like the hypogene origin advocated by Lyell; the facts as to deep-sea deposits, now in course of formation, embodied in the "Challenger" reports on that subject: the increasing discrimination and tracking of those minor divisions of strata called "zones"; the assignment of the Olenellus fauna of Cambrian age to a position earlier than that of the Paradoxides fauna; the discovery of Radiolaria in palæozoic rocks by special methods of examination, and the recognition of Graptolites as indices of geological horizons in lower palæozoic beds. Glacially eroded rocks in bowlder-clays of permo-carboniferous age have been recognized in many parts of the world (e.g., Australia and South Africa), and thus the view put forward by W. T. Blanford as to the occurrence of the same phenomena in conglomerates of this age in India is confirmed. Eozoon is finally abandoned as owing its structure to an organism. The oldest fossiliferous beds known to us are still far from the beginning of life. They contain a highly developed and varied animal fauna—and something like the whole of the older moiety of rocks of aqueous origin have failed as yet to present us with any remains of the animals or plants which must have inhabited the seas which deposited them. The boring of a coral reef initiated by Prof. Solias at the Nottingham meeting of this association in 1893 was successfully carried out, and a depth of 1,114½ feet reached. Information of great value to geologists was thus obtained.

Animal and Vegetable Morphography.—Were I to attempt to give an account of the new kinds of animals and plants discovered since 1881, I should have to read out a bare catalogue, for time would not allow me to explain the interest attaching to each. Explorers have been busy in all parts of the world—in Central Africa, in the Antarctic, in remote parts of China, in Patagonia and Australia, and on the floor of the ocean, as well as in caverns, on mountain tops, and in great lakes and rivers. We have learned much that is new as to distribution; countless new forms have been discovered, and careful anatomical and microscopical study conducted on specimens sent home to our laboratories. I cannot refrain from calling to mind the discovery of the eggs of the Australian duck-mole and hedgehog; the fresh-water jelly-fish of Regent's Park, the African lakes, and the Delaware River; the marsupial mole of Central Australia; the okapi; the young and adult of the mud-fishes of Australia, Africa, and South America; the fishes of the Nile and Congo; the gill-bearing earth worms and mud worms; the various forms of the caterpillar-like Peripatus; strange deep-sea fishes, polyps, and sponges.

The main result of a good deal of such investigation is measured by our increased knowledge of the pedigree of organisms, what used to be called "classification." The anatomical study by the Australian professors, Hill and Wilson, of the teeth and fœtus of the Australian group of pouched mammals—the marsupials—has entirely upset previous notions, to the effect that these were a primitive group, and has shown that their possession of only one replacing tooth is a retention of one out of many such teeth (the germs of which are present), as in placental mammals; and further that many of these marsupials have the nourishing outgrowth of the fœtus called the placenta fairly well developed, so that they must be regarded as a degenerate side-branch of the placental mammals, and not as primitive forerunners of that dominant series.

Speculations as to the ancestral connection of the great group of vertebrates with other great groups have been varied and ingenious; but most naturalists are now inclined to the view that it is a mistake to assume any such connection in the case of vertebrates of a more definite character than we admit in the case of starfishes, shell-fish, and insects. All these groups are ultimately connected by very simple, remote, and not by proximate ancestors, with one another and with the ancestors of vertebrates.

The origin of the limbs of vertebrates is now generally agreed to be correctly indicated in the Thatcher-Mivart-Balfour theory to the effect that they are derived from a pair of continuous lateral fins, in fish-like ancestors, similar in every way to the continuous median dorsal fin of fishes.

The discovery of the formation of true spermatozoa by simple unicellular animals of the group Protozoa is a startling thing, for it had always been supposed that these peculiar reproductive elements were only formed by multicellular organisms. They have been discovered in some of the gregarina-like animalcules, the Coccidia, and also in the blood-parasites.

Among plants one of the most important discoveries relates to these same reproductive elements, the spermatozoa, which by botanists are called antherozoids. A great difference between the whole higher series of plants, the flowering plants or phanerogams, and the cryptogams or lower plants, including ferns, mosses, and algæ, was held to be that the latter produce vibratile spermatozoa like those of animals which swim in liquid and fertilize the motionless egg-cell of the plant. Two Japanese botanists (and the origin of this discovery from Japan, from the University of Tokio, in itself marks an era in the history of science), Hirase and Ikeno, astonished the botanical world fifteen years ago by showing that motile antherozoids or spermatozoa are produced by two gymnosperms, the ging-ko tree (or Salisburya) and the cycads. The pollen-tube, which is the fertilizing agent in all other phanerogams, develops in these cone-bearing trees, beautiful motile spermatozoa, which swim in a cup of liquid provided for them in connection with the ovules. Thus a great distinction between phanerogams and cryptogams was broken down, and the actual nature of the pollen-tube as a potential parent of spermatozoids demonstrated.

When we come to the results of the digging out and study of extinct plants and animals, the most remarkable results of all in regard to the affinities and pedigree of organisms have been obtained. Among plants the transition between cryptogams and phanerogams has been practically bridged over by the discovery that certain fern-like plants of the Coal Measures—the Cycadofilices, supposed to be true ferns, are really seed-bearing plants and not ferns at all, but phanerogams of a primitive type, allied to the cycads and gymnosperms. They have been rechristened Pteridosperms by Scott, who, together with F. Oliver and Seward, has been the chief discoverer in this most interesting field.

By their fossil remains whole series of new genera of extinct mammals have been traced through the tertiary strata of North America, and their genetic connections established; and from yet older strata of the same prolific source we have almost complete knowledge of several genera of huge extinct Dinosauria of great variety of form and habit.

The discoveries of Seeley at the Cape, and by Amalitzky in North Russia of identical genera of Triassic reptiles, which in many respects resemble the Mammalia and constitute the group Theromorpha, is also a prominent feature in the palæontology of the past twenty-five years. Nor must we forget the extraordinary Silurian fishes discovered and described in Scotland by Prof. Traquair. The most important discovery of the kind of late years has been that of the Upper Eocene and Miocene mammals of the Egyptian Fayum, excavated by the Egyptian Geological Survey and by Dr. Andrews, of the Natural History Museum, who has described and figured the remains. They include a huge four-horned animal as big as a rhinoceros, but quite peculiar in its characters—the Arsinoitherium—and the ancestors of the elephants, a group which was abundant in Miocene and Pliocene times in Europe, and Asia, and in still later times in America, and survives at the present day in its representatives, the African and Indian elephant. One of the European extinct elephants—the Tetrabelodon—had, we have long known, an immensely long lower jaw with large chisel-shaped terminal teeth. It had been suggested by me that the modern elephant's trunk must have been derived from the soft upper jaw and nasal area, which rested on this elongated lower jaw, by the shortening (in the course of natural selection and modification by descent) of this long lower jaw, to the present small dimensions of the elephant's lower jaw, and the consequent down-dropping of the unshortened upper jaw and lips, which thus become the proboscis. Dr. Andrews has described from Egypt and placed in the museum in London specimens of two new genera—one Palæomastodon, in which there is a long, powerful jaw, an elongated face, and an increased number of molar teeth; the second, Meritherium, an animal with a hippopotamus-like head, comparatively minute tusks, and a well-developed complement of incisor, canine, and molar teeth, like a typical ungulate mammal. Undoubtedly we have in these two forms the indications of the steps by which the elephants have been evolved from ordinary-looking pig-like creatures of moderate size, devoid of trunk or tusks. Other remains belonging to this great mid-African Eocene fauna indicate that not only the elephants but the Sirenia took their origin in this area. Among them are also gigantic forms of Hyrax, like the little Syrian coney and many other new mammals and reptiles.

(To be continued.)

Researches upon the metal cæsium have been carried out by E. Rengade, of Paris. Seeing that the metal cæsium has the property of igniting spontaneously when brought in contact with air, it seemed of interest to find out whether this action is not due to the presence of moisture, and to observe how the metal acts when in contact with pure and dry oxygen. The apparatus which is used here consists of a horizontal glass tube. At one end it connects with an oxygen supply or a mercury pump. The cæsium is contained in an aluminium tray. After making a vacuum, we introduce oxygen in small quantity, and the metal now melts and oxidizes at once, absorbing all the gas. As it was supposed that the apparatus might contain a slight trace of moisture, another form was used. A small glass bulb having a fine point containing the metal distilled *in vacuo* is inclosed in an oxygen tube. In the bottom are some pieces of metaphosphoric acid. After several weeks the small tube is given a shock, so as to break off the point. In this case we have a sudden oxidation of the metal and it glows brightly. At low temperature the action is less. At —40 deg. C. the metal soon blackened, but it does not glow, while at —80 deg. C. the effect is much slower. The apparatus just described also serves to observe the oxidation products in cæsium. If we allow oxygen to arrive slowly over the aluminium vessel, a liquid is first produced having gold reflections, resembling the ammonium metals. With a new supply of oxygen it is soon changed to a black mass. Then the oxidation stops, and the metal must be heated to go further. The mass swells up at first, and then contracts. No doubt a series of oxides are thus formed. If we heat the product in oxygen up to a definite fusion and let it cool we obtain a yellow crystalline mass. Analysis gives the formula Cs_2O_4 for this oxide. The aluminium tray is not attacked when quite dry, but other metals such as platinum, gold, silver, also glass, are strongly attacked under the same conditions. The oxide of cæsium which is thus prepared is of a golden yellow color and is darker when hot. Its density is 3.77 at 19 deg. C. Its fusing point in an oxygen chamber is 515 deg. C. This body is decomposed at once by water, giving off oxygen and forming hydroxyl according to the reaction $Cs_2O_4 + 2\,H_2O = 2\,CsOH + O_2 + H_2O_2$. Carbonic acid has no action on it when cold, but when slightly heated it gives the reaction $CO_2 + Cs_2O_4 = CO_3Cs_2 + O_2$. Dry hydrogen reduces the peroxide of cæsium near 300 deg. C., giving off oxygen and water vapor. The reaction is complex in this case. The first effect of the hydrogen is to form water vapor, and the latter then acts partially upon the remaining peroxide, decomposing it and giving off oxygen. It also attacks the aluminium trough, which is much corroded, with formation of aluminate of cæsium at the same time as the hydrate of the metal.

PHOSPHORESCENCE OF RARE EARTHS.—G. Urbain has studied the rare earths europium, gadolinium, terbium and dysprosium, and found that they all have a constant atomic weight, a characteristic spark spectrum and absorption spectrum, and also a phosphorescence spectrum when exposed to cathode rays. But the author finds that the oxides of these metals are not at all phosphorescent, or very slightly, when in a pure state. Mixtures of several of them are, however, highly phosphorescent. When one of them is added to another in increasing proportions, the phosphorescence passes through a maximum of brightness while the percentage is below one. Thus, in the case of a mixture of gadolinium and europium, the maximum phosphorescence is obtained when the europium oxide amounts to about 1 part in 250 of the mixture. The appearance of the phosphorescence spectrum is the same as if the gadolinium were replaced by calcium. Hence it is an atomic property of the europium, practically unaffected by the "solvent," whether calcium or gadolinium. The author has, by this principle, been able to identify several apparently unknown phosphorescent spectra as those of well-known bodies in a certain state of dilution.—G. Urbain, Société Française de Physique, Résumé, February 2, 1906.

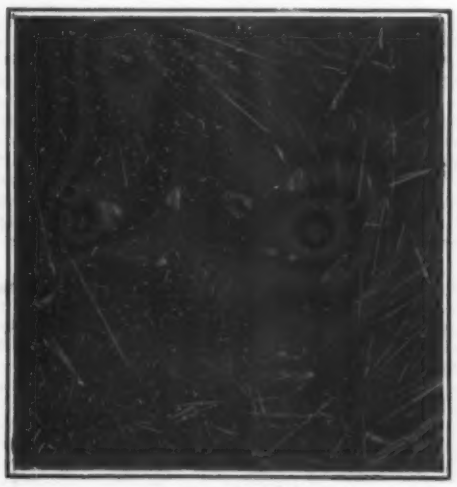
TWO FOX CUBS AND THEIR FOSTER MOTHER.

By OXLEY GRABHAM.

IN the course of a long experience one comes across many curious and interesting cases of foster-mothers rearing and taking under their protection young animals of their own and far different species. For instance, I have known a terrier suckle and bring up a litter of kittens, a collie bring in from the fields a young wild rabbit and rear it, another collie mother a young chicken, a cow suckle two young lambs, a cat a couple of young squirrels, another cat mother a chicken which had broken its leg, and allow nothing to come near it; and the other day, Mr. W. Cooper of Aislaby Hall, near Pickering, informed me that a groom in the employ of Mr. Frank Stericker of Pickering, Yorkshire, had a cat which was suckling two little fox cubs.

I accordingly wrote to Mr. Stericker, asking if I might run over and photograph such an interesting group, and, my request being at once most courteously acceded to, I went to Pickering on April 28, and obtained a most interesting series of photographs, some of which are here reproduced. Mr. Stericker informed me that the two little cubs had been found ten days previously by his man in a fence bottom, quite helpless and blind, and apparently only a day or two old. Not seeing any sign of a vixen about, or any trace of an earth near, he thought they would only come to an untimely end if he left them where they were, and so he put them in his pocket and took them back to the stable, where he had a cat with a recently-produced family of kittens. The little cubs were at first put with the kittens, and the old cat took to them at once, paying as much attention to them as she did to her own family. When they had been with her a few days the kittens were removed, so that the young cubs might obtain all the nourishment possible; and at the time of my visit, when they were about a fortnight old, they were strong, hardy little animals, with every prospect of being successfully reared. And a very pretty sight it was to see the old cat playing with them, now rolling on her back and now on her side, and the little foxes, with their distinctly white-tagged brushes, cuddling up to her, and giving little yaps and growls of pleasure and contentment. In their soft mouse-colored fluffy coats they presented a very different appearance to what they will do if they are fortunate enough to survive their cubhood and in due course blossom out into full-grown foxes. The old cat at first did not at all approve of the intrusion of a stranger with a camera into the family circle, and she glared at me angrily, and lashed her tail from side to side; but with the assistance of Mr. Stericker and his man she soon settled down with her foster-children, and the whole group formed as pretty and interesting a picture as I have had the pleasure of seeing for a long time.

With regard to the finding of fox cubs above ground when they are very young indeed, in fact only a few days old, my experience is that the vixens very frequently drop their cubs above ground, and then at a subsequent date either scratch out a temporary earth for their reception, or else take them to some well-established one near at hand. It is not by any means the case that the family always comes into this troublesome world below ground, as many people believe. I have only known of two instances where vixens have made their nurseries up in a tree; one case was not far from York some years ago, when a boy who had got up a tree to look for a brown owl's nest—it was an old pollard willow—on putting his hand into the hole, bolted to his great surprise and fright a fine vixen, who got out of an exit there was on the other



A MONTH OLD.

side of the tree. Fortunate was it for the lad that there was such an exit, otherwise he would have been badly bitten, and as it was he was very lucky to escape untouched. There were three little cubs in the hollow, but the next morning, on the farmer coming down to look at them, they were found to have disappeared, the old vixen evidently having removed them during the night. The other case, for information as to which I am indebted to Mr. Hounslow, head keeper on the Wass Estate, near Coxwold, Yorks, occurred in a hollow tree on that property. The hole was situated nearly thirty feet from the ground, and contained a litter of young cubs of the extraordinary number of ten. This I should imagine is almost a record.—Country Life (London).

REMEDIES AND PREVENTIVES AGAINST HOUSE FLIES.

A careful screening of windows and doors during the summer months, with the supplementary use of

EARLY DAYS.

A LITTLE RED ROVER.

sticky fly papers, is a preventive measure against house flies known to everyone, and there seems to be little hope in the near future of much relief by doing away with the breeding places. A single stable in which a horse is kept will supply house flies for an extended neighborhood. People living in agricultural communities will probably never be rid of the pest, but in cities, with better methods of disposal of garbage and with the lessening of the number of horses and horse stables consequent upon electric street railways, bicycles, and automobiles, the time may come, and before very long, when window screens may be discarded. The prompt gathering of horse manure, which may be variously treated or kept in a specially prepared receptacle, would greatly abate the fly nuisance, and city ordinances compelling horse owners to follow some such course are desirable. Absolute cleanliness, even under existing circumstances, will always result in a diminution of the numbers of the house fly, and, in fact, most household insects are less attracted to the premises of what is known as the old-fashioned housekeeper than to those of the other kind.

During the summer of 1897 a series of experiments was carried out with the intention of showing whether it would be possible to treat a manure pile in such a way as to stop the breeding of flies. Mr. L. O. Howard's experience with the use of air-slaked lime on cow manure to prevent the breeding of the horn fly suggested experimentation with different lime compounds. It was found to be perfectly impracticable to use air-slaked lime, land plaster, or gas lime with good results. Few or no larvæ were killed by a thorough mixing of the manure with any of these three substances. Chlorid of lime, however, was found to be an excellent maggot killer. Where 1 pound of chlorid of lime was mixed with 8 quarts of horse manure, 90 per cent of the maggots were killed in less than twenty-four hours. At the rate of a quarter of a pound of chlorid of lime to 8 quarts of manure, however, the substance was found not to be sufficiently strong. Chlorid of lime, though cheap in Europe, costs at least 3½ cents a pound in large quantities in this country, so that the frequent treatment of a large manure pile with this substance would be out of the question in actual practice.

Experiments were therefore carried on with kerosene. It was found that 8 quarts of fresh horse manure sprayed with 1 pint of kerosene, which was afterward washed down with 1 quart of water, was thoroughly rid of living maggots. Every individual was killed by the treatment. This experiment and others of a similar nature on a small scale were so satisfactory that it was considered at the close of the season that a practical conclusion had been reached, and that it was perfectly possible to treat any manure pile economically and in such a way as to prevent the breeding of flies.

Practical work in the summer of 1898, however, demonstrated that this was simply another case where an experiment on a small scale has failed to develop points which in practical work would vitiate results.

The stable of the U. S. Department of Agriculture, in which about twelve horses are kept, is situated about 100 yards behind the main building of the Department and about 90 yards from the building in which the Bureau of Entomology is situated. This stable has always been very carefuly kept. The manure was thoroughly swept up every morning, carried outside of the stable, and deposited in a pile behind the building. This pile, after accumulating for a week or ten days, or sometimes two weeks, was carried off by the gardeners and spread upon distant portions of the grounds. At all times in the summer this manure pile swarmed with the maggots of the house fly. It is safe to say that on an average many thousands of perfect flies issued from it every day, and that at least a large share of the flies in the two buildings mentioned came from this source.

On the basis of the experiments of 1897, an attempt was made, beginning early in April, 1898, to prevent the breeding of house flies about the department by the treatment of this manure pile with kerosene. The attempt was begun early in April and was carried on for some weeks. While undoubtedly hundreds of thousands of flies were destroyed in the course of this work, it was found by the end of May that it was far from perfect, since if used at an economical rate the kerosene could not be made to penetrate throughout the whole pile of manure, even when copiously washed down with water. A considerable proportion of house-fly larvæ escaped injury from this treatment, which at the same time was found, even at an economical cost, to be laborious, and such a measure, in fact, as almost no one could be induced to practically adopt.

There remained, however, another measure which had been suggested by Mr. Howard in an article on the house fly published in 1895, namely, the preparation of an especial receptacle for the manure, and this was very readily accomplished. A closet 6 by 8 feet had been built in the corner of the stable nearest the manure pile. It had a door opening into the stable proper, and also a window. A door was built in the outside wall of this closet, and the stablemen were directed to place no more manure outside the building; in other words, to abolish the outside manure pile, and in the future to throw all of the manure collected each morning into this closet, the window of which in the meantime had been furnished with a wire screen. The preparations were completed by the middle of June, and a barrel of chlorid of lime was put in the corner of the closet. Since that time every morning the manure of the stable is thrown into the closet, and a small shovelful of chlorid of lime is scattered over it. At the expiration of ten days or two weeks the gardeners open the outside door, shovel the manure into a cart, and carry it off.

Judging from actual examination of the manure pile, the measure is eminently successful. Very few flies are breeding in the product of the stable which formerly gave birth to many thousands daily. After this measure had been carried on for two weeks, employees of the Department who had no knowledge of the work that was going on were asked whether they had noticed any diminution in the number of flies in their offices. Persons in all of the offices on the first floor of the two buildings were asked this question. In every office except one the answer was that a marked

AFTER SIX WEEKS.

decrease had been noticed, so that the work must be considered to have been successful.

The account of this remedial work has been given with some detail, since it shows so plainly that care and cleanliness combined with such an arrangement as that described will in an individual stable measurably affect the fly nuisance in neighboring buildings.

With the combined efforts of the persons owning stables in a given community, much more effective results can undoubtedly be gained.—Abstracted from a Bulletin by L. O. Howard, Chief of the Bureau of Entomology, Department of Agriculture.

THE MYSTERIOUS PLANET SATURN.

By FELIX EBER.

ON a memorable evening in the year 1610 Galileo sat in the tower of his observatory in Florence, and gazed through his newly-invented "perspective glass" at Saturn, which was then regarded as the most distant of the planets. The astronomer was astonished to see the planet flanked by two smaller globes, one on each side, and with characteristic prudence, and in accordance with the fashion of the age, he made a record of his discovery in the form of an anagram, which admitted an almost infinite number of interpretations, and sorely tried the patience of the indomitable Kepler, until the answer to the riddle appeared in Galileo's letter to Giuliano de'Medici. Two years later, however, Galileo found that these attendants of Saturn had vanished. The inexplicable character of these discoveries is said to have vexed Galileo so greatly, that he never deigned to cast another glance on the mysterious planet.

Later observers have been deceived in the same way. Saturn surrounded by its rings appeared to Scheiner and Hevel, in 1614, as a disk with two projecting ears. The Jesuit priest Eustachius de Divinis, in 1647, and Riccioli, in 1648, made a close approximation to the real form of the planet, but the mathematically-trained Huygens, in 1655, first described it

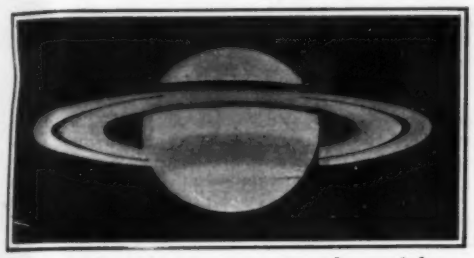


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FIG. 1.—SATURN AND ITS RINGS, AS DRAWN IN 1894 BY LEO BRENNER, DIRECTOR OF THE MANORA OBSERVATORY AT LUSSINPICCOLO.

1. Encke's line. 2. Cassini's division. 3. The gauze or crape ring.

correctly as being "surrounded by a thin flat ring, nowhere in contact with it, and inclined to the ecliptic."

Saturn, with its rings and satellites, forms so true a picture of an early stage in the development of the solar system according to Laplace's theory of cosmogony, that one is almost tempted to regard it as a living proof of the correctness of that hypothesis.

From the newer and more probable meteoric theory the late English astronomer Proctor derived the conclusion that Saturn is the second planet of the solar system in order of creation. This theory assumes that in the beginning the entire field of the solar system was filled with solid particles of cosmical matter which, coalescing in consequence of mutual collisions, formed first a principal nucleus of attraction (the sun) and then subordinate nuclei (the planets), each of which, as it revolved around the sun, captured all the remaining particles that came within its sphere of attraction.

Saturn is but faintly illuminated by the sun, its mean distance from which is nearly 900 million miles. The Hindus called it "Sanaistshara," (slowly moving—a name given also to Vishnu in the Vedas), because the planet so leisurely follows the eastward course of the sun among the stars, tarrying two years and six

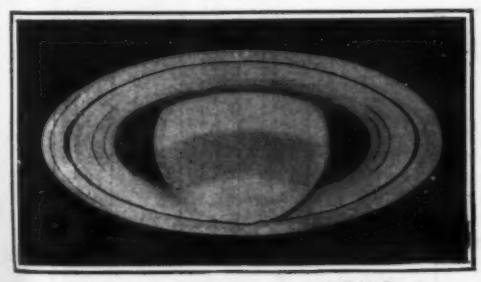

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FIG. 2.—SATURN AND ITS RINGS, AS DRAWN IN 1898 BY LEO BRENNER.

1. Encke's pencil line. 2. Cassini's division. 3. Secchi's line. 4. Bond's line. 5. Manora line. 6. Struve's line.

months in each constellation of the zodiac, through which the sun passes in a single month. This apparent motion of the planet, however, is not uniform, but is affected by the periodic shifting of our point of view, the earth, so that Saturn is not always easily found and distinguished among the stars.

When the planet is viewed through a large telescope, it is seen to be greatly flattened at the poles. Saturn has been weighed in the astronomer's balance, and found to contain twice as much matter as Mercury, Venus, the earth, Mars, Uranus, and Neptune combined. Its mass is 93 times that of the earth, and Jupiter alone exceeds it in magnitude. The equatorial diameter of Saturn is about 73,000 miles, but the polar diameter is only 66,000 miles. The great planet consumes 29½ of our years in making one revolution around the sun, from which its mean distance is about 895 million miles. At this distance the intensity of solar radiation is only 1-90 of that which falls on the earth. It might be inferred from this fact that Saturn must have an Arctic climate and be covered with glaciers, but ice caps, like those of Mars, have never been observed at the poles of Saturn.

FIG. 3.—SATURN'S RINGS AS THEY WOULD APPEAR TO AN OBSERVER ON THE PLANET, FIFTY DEGREES FROM THE EQUATOR.

Hence we are justified in assuming that Saturn is still hot and, to some extent, self-luminous. Very probably it is yet in the stage of crust formation and preparation for the development of organic life, or in the stage of cooling through which the earth passed millions of years ago, when it was covered with forests of huge ferns and grasses and inhabited by gigantic saurians.

Each of the four seasons of Saturn's year continues through seven of our years. The inclination of its equator to the plane of its orbit, 27 degrees, is such as to make the distribution of climate and the phenomena of change of seasons similar to those of Mars and the earth. Saturn not only possesses an atmosphere, in which Joussen has found spectroscopic indications of the presence of hydrogen, but is enveloped in a mantle of dense clouds, as the earth was millions of years ago and Jupiter is to-day.

The spectrum of Saturn is very similar to that of Jupiter. Both show dark absorption bands in the red and orange, which point to a close resemblance in the physical constitution of the two great planets. In the vapors which envelop both, also, peculiar cloud masses have been observed, including dark bands parallel to the equator. In the case of Saturn these phenomena are very variable, and are indistinct because of the feeble illumination which the planet receives from the sun. From them, however, Sir William Herschel computed the period of rotation at 10 hours and 16 minutes.

In 1876 a very bright spot appeared near the equator of Saturn, and remained visible for several months. Like the red spot once seen on Jupiter, it was probably the result of some great convulsion on the surface of the planet. From the motion of this spot, Prof. Asaph Hall, director of the Naval Observatory at Washington, deduced a period of rotation of 10 hours, 14 minutes, and 24 seconds. These figures, however, were only provisional. The atmospheric strata of Saturn do not rotate at the same rate as the body of the planet, and, moreover, these spots and clouds have relative motion with respect to the atmosphere. In 1903 very conspicuous but variable dark and bright spots appeared on the northern hemisphere of Saturn, indicating another series of great atmospheric disturbances.

From all the spectroscopic and other observations which bear upon the rotation of Saturn, a period of 10 hours, 14 minutes, and 6 seconds—nearly identical with Hall's result—has been deduced as the most probable value. This rapid rotation greatly reduces the weight of objects at the equator, where gravity would be entirely neutralized by centrifugal force if the planet rotated 2½ times faster than it actually does.

For the time of rotation of Saturn's ring, Laplace gave the value 10 hours, 29 minutes, and 17 seconds. More recent observations give 7 hours and 45 minutes for the inner edge of the first bright ring, and 5 hours and 39 minutes for the inner edge of the innermost, or "gauze" ring. The mean time of rotation of the rings, however, is greater than this, and is estimated as equal to 10 hours and 29 minutes, a value almost identical with that given by Laplace.

The series of nearly concentric rings that encircle Saturn in the equatorial plane appears like a survival of primordial conditions. It is the most astonishing object that is visible in the solar system or that could well be imagined. There are three principal rings and several minor subdivisions. The innermost, dimly-shining ring, called the "gauze" or "crape" ring, begins at a distance of 6,400 miles from the surface of the planet, and is 8,400 miles wide. This ring was discovered in 1836 by Galle, the discoverer of Neptune, and was carefully studied by Bond and Dawes. Astronomers have detected or fancied numerous subdivisions in this faint ring, which is now generally regarded as a cloud of cosmical dust, similar to the cloud that causes the phenomenon of the zodiacal light. The disk of Saturn is seen through this ring in undiminished brightness, and in May, 1905, Saturn's satellite Iapetus passed bodily through the gauze ring. The circumstances and consequences of this passage proved that the gauze ring is composed of separate particles, which are either smaller or less closely aggregated than those which form the outer rings. The gauze ring merges by imperceptible gradations into a moderately bright ring about 18,000 miles wide, which is separated by an interval of 1,450 miles known as "Cassini's division," from the outer very bright ring, the breadth of which is 10,000 miles. The outer edge of the exterior ring is about 45,000 miles distant from the surface of the planet. This remarkable series of rings, which surrounds Saturn as the brim of a hat surrounds the wearer's head, possesses no atmosphere, for the characteristic atmospheric line in the red is absent from its spectrum.

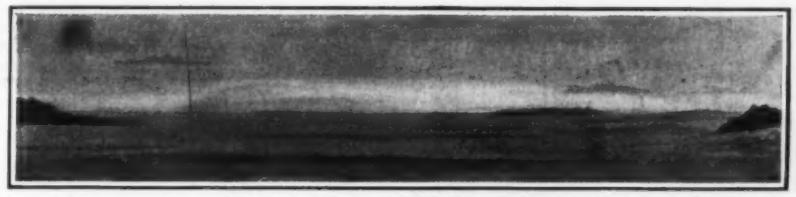

FIG. 4.—SATURN'S RINGS AS THEY WOULD APPEAR TO AN OBSERVER ON THE PLANET, SEVENTY DEGREES FROM THE EQUATOR.

Twice in each revolution of the planet about the sun the rings vanish or dwindle to a narrow line, and twice they open into the broad ovals shown in Fig. 2. These are the changes which so greatly puzzled and annoyed Galileo. When the plane of the rings passes through the sun, an event which occurs whenever, as at present, Saturn in opposition is found in the constellation Pisces or the constellation Leo, the rings disappear. When the planet is in opposition in Sagittarius, or between Taurus and Gemini, the rings appear broadest, and Saturn shines more brightly than a star of the first magnitude. Finally, when the rings are invisible and the planet near conjunction, it appears like a star of the magnitude 1½. An interval of seven years and four months elapses between the maximum brightness and the disappearance of the rings as described above. But the rings are likewise invisible whenever their plane passes between the earth and the sun, because their illuminated side is turned away from us. In this case we see only the shadow cast by the rings on the planet. A very fine drawing of the shadow as observed in 1856 was made by Secchi, and the shadow has often been drawn from observation by other astronomers. From the breadth of the shadow it is inferred that the rings are about 60 miles thick. To an inhabitant of Saturn the rings would present a wonderful picture at night, spanning the landscape like an immense rainbow, colorless but

FIG. 5.—RELATIVE DISTANCES OF THE SATELLITES FROM SATURN.

The actual mean distance between Saturn and Phœbe is 8,000,000 miles.

dazzling. By day, however, they would eclipse the sun in the regions covered by their shadow.

Viewed through the small telescope of early observers, the rings appeared as one. In 1665 Ball discovered indications of the principal dark line of division, which was afterward seen more distinctly by Maraldi and Cassini and named "Cassini's division." Encke discovered a much finer line, which is called "Encke's pencil line," and later observers have increased the number of distinct rings to seven or more (Fig. 2).

The intervals between the rings may be compared with the void spaces in the asteroid belt, where asteroid orbits are made impossible by the disturbing influence of the great planets. The rings of Saturn, if they are not continuous masses of cosmical matter, must be swarms of billions of small satellites, each of which travels in its individual orbit subject to the attractions of all the rest and of all other bodies in the universe, in accordance with the inexorable law of gravitation. Probably the complex motions of this vast swarm of satellites have become so adjusted that no collisions occur.

Saturn's ring was long believed to be a continuous solid mass. Bond and Peirce regarded it as liquid, but in 1884 Pratt discovered a distinct granulation which suggested its true nature. Now we know with certainty from the photometric investigations of Seeliger, of Munich, that the rings are made up of countless separate particles, which change their relative positions, and that the apparent continuity is merely an effect of distance. The talented and prematurely deceased American astronomer Keeler proved by spectroscopic observations interpreted by Döppler's principle that the inner parts of the ring move more swiftly in a radial direction (in the line of vision) than the outer parts. Hence the ring can not be a rigid mass.

Saturn also possesses at least nine larger satellites or moons, and probably a tenth (Thermis). The following table gives the principal data concerning these satellites:

Order of Distance from Saturn	Name of Satellite	Discover.	Date of Discovery.	Time of Revolution		Distance from Center of Saturn in Saturn's Radii.
				Days	Hrs.	
1	Mimas	Sir Wm. Herschel.	1789	0	23	3
2	Enceladus	Sir Wm. Herschel.	1789	1	9	4
3	Thetis	D. Cassini	1684	1	21	5
4	Dione	D. Cassini	1684	2	18	6
5	Rhea	D. Cassini	1672	4	12	8½
6	Titan	Huygens	1655	15	23	20
8	Hyperion	Bond and Lassel	1848	21	7	24
9	Iapetus	D. Cassini	1671	79	8	57
10	Phœbe	H. W. Pickering	1898	546	12	207
7	Themis	H. W. Pickering	1905	.....	....	.....

Phœbe was first actually seen by Barnard in 1904, after its motions had been photographically traced for years. It is only about 60 miles in diameter. Its motion was long thought to be retrograde, but this question, with that of the existence of the tenth satellite, must be left to the future for final answer. The satellite Iapetus is peculiarly interesting because of its periodic changes in brightness, which are probably due to differences in the character of its surface at different points.

Our present knowledge of Saturn makes it certain that neither the planet nor its rings can be inhabited by creatures at all resembling human beings. It is not improbable, however, that the surface of the planet may have cooled sufficiently to develop a flora and a fauna similar to those which occupied the earth in the carboniferous period.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Illustrirte Zeitung.

THE NUTRITIVE VALUE OF CEREAL BREAKFAST FOODS.*

THE constituents of all foods are water, protein, fats, carbohydrates, and mineral matter or ash. Water, though needed in considerable quantities by the body, is obtained from beverages as well as from solid food and does not count as one of the nutritive materials or nutrients of food. It might be left entirely out of consideration in discussions like this save that its presence in food decreases the proportion of nutrients. Protein is the foundation of all the tissues of the body and is an indispensable food ingredient. It is also the most costly of all nutrients. The carbohydrates include the various kinds of sugars and starches, commonly grouped together under the name nitrogen-free extract. Cellulose, or crude fiber, which forms the woody or straw-like framework of plants, also belongs to the carbohydrate group. It is here considered separately, because, while the other carbohydrates are valuable nutrients, crude fiber is so indigestible that it has almost no food value. It is, however, undoubtedly useful in giving the needed bulk to the food. The fats include the numerous fats and oils in the diet, like those of butter, cream, fat of meat, olive oil, etc. Mineral matter or ash includes phosphates, chlorids, and other salts of calcium, magnesium, sodium, potassium, iron, etc.

The nutrients supplied in the food enable the body to grow and to repair its tissues as they are worn out in the necessary exercise of the body functions. Another of the great uses of food is to supply the body with the energy needed for its various activities and for keeping up body heat. During digestion, assimilation and utilization, food undergoes great chemical changes in the body, many of which liberate heat. It is through such chemical processes that the energy required for internal and external muscular work is provided and the body temperature maintained. Energy may be very conveniently measured in terms of heat, the calorie* or heat unit being used for this purpose. It quite naturally follows that the amount of energy which the body gets from any food is spoken of as its fuel value. All the nutrients except mineral matters are sources of energy, but since protein, the only nutrient containing nitrogen, has tissue-building functions which the other nutrients do not possess, the body usually finds it more economical to use fat and carbohydrates largely as energy-yielding foods. As sources of energy fats are more concentrated than protein and carbohydrates, one pound of digestible fat supplying 4,260 calories of heat or energy, or about two and one-fourth times as much as a pound of protein or carbohydrates, which yields, respectively, 2,000 and 1,860 calories.

The terms digestion and digestible as commonly used frequently refer to ease or quickness of digestion or to the "agreement" of a given food with an individual. In physiological discussions "digestibility" more commonly refers to the thoroughness with which a food is absorbed—that is, the amount or percentage of nutrients retained by the body when food passes through the digestive tract. Digestibility may be determined by actual experiments or, when experiments cannot be conveniently undertaken, may be calculated with reasonable accuracy by the aid of standard factors, which have been derived from actual experiments.

In Table 2 the results of a large number of digestion experiments with cereal breakfast foods are summarized. These average values were used in computing the results given in Table 1, showing the average composition of various sorts of cereal breakfast foods, the proportion of digestible nutrients which they supply, and the energy of value of the digestible nutrients. For purposes of comparison some other common foods are also included in the table. In this and other tables the different cereal breakfast foods are arranged in groups, but trade names are not used. If the housewife who is interested in any special brand will take note of its physical characteristics and appearance, she should be able to determine the class in which it should be included, and so decide as to its comparative value.

Different specimens of the same grain show considerable variations in composition, depending upon such factors as the variety, the soil, the climate, and the season in which they are grown. The cereal breakfast foods and other materials prepared from the grains naturally show a corresponding range in composition, but in general are quite similar in composition to the grains from which they are made. The methods of hulling, milling, and manipulation to which the breakfast foods and similar goods are submitted naturally exercise some effect on composition. Thus, two specimens of oatmeal may vary in the amount of crude fiber which is left in the manufactured product, or one brand of rice or pearled barley may be polished down more thoroughly than another. It is believed, however, that the figures in the annexed table, which are based on a large number of analyses, are representative, and that they show average values for various products as they are found in American markets.

The analytical data summarized in the table show that the grains and the products made of them, as is obvious from their appearance, are comparatively dry materials, the average water content of the uncooked material being not far from 10 per cent. The cereal grains and their products have a fairly high protein content, but the carbohydrates, especially nitrogen-free extract, make up the nutrient group present in the largest proportion. The fat content, though never large, varies within rather wide limits, being greatest in corn and oats and their products and lowest in rice. The proportion of ash in cereals is small, as indeed is the case with all the common food products. Some variation is observed, the coarser grain products containing rather more ash than those made up of the interior portion of the grain. Such differences are, however, too small to be of much account in an ordinary diet, since the amount of ash constituents supplied will almost always be more than sufficient for all needs.

In comparing the composition of the different cereals it is apparent that while they resemble each other closely and all are rich in carbohydrates, there are certain differences between them which are quite characteristic. Thus, corn is characterized by a relatively high proportion of fat; oats are relatively rich in both protein and fat; rice is comparatively free from crude fiber and fat; wheat and rye have a high proportion of protein with a moderate amount of fat, while barley and wild rice contain about average proportions of all the nutritive ingredients. Judged by their chemical composition alone, that is, by the total amount of nutrients furnished, of the six most important cereal grains, namely, wheat, oats, rice, corn, rye, and barley, oats appear to furnish the nutrients in better proportions than the other cereals. Wheat ranks very close to oats and corn next to wheat.

The hulling and other processes followed in the manufacture of cereal breakfast foods frequently remove some of the crude fiber of the outer layers of the grain and so many of the manufactured products contain less of this indigestible material than the original grain. In general, however, a comparison of the cereal breakfast foods and the grains from which they are made shows that the manufactured products are very similar in composition to the original grain. This is what might be expected when it is remembered that

* A calorie represents very nearly the amount of heat required to raise the temperature of 1 pound of water from 0 deg. to 4 deg. F.

* Abstracted from Farmer's Bulletin 249, issued by the Department of Agriculture.

TABLE I.—TOTAL AND DIGESTIBLE NUTRIENTS AND FUEL VALUE OF CEREAL BREAKFAST FOODS AND SOME OTHER FOODS.

Kind of Food.	Proportion of Total Water and Nutrients in Food.						Proportion of Digestible Nutrients in Food.				Fuel Value per Pound.
	Water.	Protein.	Fat.	Carbohydrates. Nitrogen-Free Extract.	Carbohydrates. Fiber.	Ash.	Protein.	Fat.	Carbohydrates.	Ash.	
	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Cals.
Oat Preparations:											
Oats, whole grain	11.0	11.8	5.0	59.7	9.5	3.0	....	....	....	....	.....
Oatmeal, raw	7.3	16.1	7.2	68.6	0.9	1.9	12.5	6.5	65.5	1.4	1,767
Rolled oats, steam-cooked	8.2	16.1	7.4	65.2	1.3	1.8	12.5	6.7	64.5	1.4	1,759
Flaked and malted oats	7.9	18.2	5.2	66.7	1.6	2.4	12.6	4.7	66.3	1.8	1,709
Flaked oats, to be eaten raw	8.6	13.1	7.8	68.8		1.7	10.2	7.0	68.7	1.3	1,742
Wheat:											
Whole grain	10.5	11.9	2.1	71.9	1.8	1.8	....	....	....	....	.....
Cracked wheat	10.1	11.1	1.7	73.8	1.7	1.6	8.1	1.5	68.7	1.2	1,501
Rolled wheat, steam-cooked	10.6	10.2	1.8	74.1	1.8	1.5	8.5	1.6	70.7	1.1	1,541
Flaked and crisped, ready to eat	9.4	12.2	1.4	72.7	1.9	2.4	8.9	1.3	67.9	1.8	1,500
Flaked, crisped and malted, ready to eat	9.0	12.1	1.4	73.0	1.8	2.7	9.1	1.3	68.4	2.0	1,526
Shredded wheat	8.1	10.6	1.4	76.0	2.1	1.8	7.7	1.3	71.1	1.4	1,521
Coarsely ground, parched at factory	8.0	14.2	3.1	72.3	1.0	1.4	11.5	2.8	70.1	1.1	1,699
Crumbed and malted	5.6	12.2	1.0	77.6	1.7	1.9	9.1	0.9	73.7	1.4	1,623
Coarsely ground, decorticated	9.6	12.5	1.0	76.0	0.5	0.4	10.1	0.9	73.1	0.3	1,622
Flaked, to be eaten raw	10.0	0.9	2.1	79.2		1.8	7.2	1.9	69.3	1.4	1,500
Farina	10.9	11.0	1.4	75.9	0.4	0.4	8.9	1.3	72.9	0.9	1,609
Patent roller process flour	12.0	11.4	1.0	74.8	0.3	0.5	....	....	....	....	1,650
Entire wheat flour	11.4	13.8	1.9	71.0	0.9	1.0	....	....	....	....	1,675
Graham flour	11.3	13.3	2.2	69.5	1.9	1.8	....	....	....	....	1,670
Rye:											
Whole grain	11.6	10.6	1.7	72.5	1.7	1.9	....	....	....	....	.....
Flaked, to be eaten raw	11.1	10.0	1.4	75.8		1.7	7.8	1.3	71.1	1.3	1,526
Barley:											
Whole grain	10.9	12.4	1.8	69.8	2.7	2.4	....	....	....	....	.....
Pearled barley	11.5	8.5	1.1	77.5	0.3	1.1	0.6	1.0	73.0	0.8	1,514
Flaked, steam-cooked	8.8	10.6	0.8	77.7	1.2	0.9	8.2	0.7	74.0	0.7	1,560
Flaked, to be eaten raw	10.8	8.9	1.1	77.9		1.3	6.9	1.0	73.1	1.0	1,525
Buckwheat:											
Flour	13.6	6.4	1.2	77.5	0.4	0.9	5.0	1.1	73.1	0.7	1,471
Farina	11.3	3.3	0.3	84.0	0.1	0.4	2.6	0.3	79.4	0.3	1,480
Groats	10.6	4.8	0.6	83.1	0.3	0.6	3.7	0.5	78.2	0.5	1,503
Corn:											
Whole grain	10.9	10.5	5.4	69.6	2.1	1.5	....	....	....	....	.....
Corn meal, unbolted	11.6	8.4	4.7	74.0		1.3	6.2	4.2	73.2	1.0	1,728
Corn meal, bolted	12.5	9.2	1.9	74.4	1.0	1.0	6.8	1.7	74.6	0.8	1,662
Hominy	10.9	8.6	0.6	79.2	0.4	0.3	6.4	0.5	78.7	0.2	1,671
Flaked, parched	7.3	10.1	1.8	77.2	1.2	2.4	7.5	1.6	77.5	1.8	1,734
Pop corn, popped	4.3	10.7	5.0	77.3	1.4	1.3	7.9	4.5	77.8	1.0	1,882
Hulled corn	74.1	2.3	0.9	22.2		0.5	1.7	0.8	21.8	0.4	492
Rice:											
Whole rice, polished	12.3	0.9	0.3	80.0		0.5	5.8	0.3	78.4	0.4	1,546
Flaked, steam-cooked	10.2	8.3	0.3	79.7	1.2	0.3	6.9	0.3	79.2	0.2	1,596
Puffed rice	7.1	6.2	0.6	85.7		0.4	5.1	0.5	84.0	0.3	1,630
Popped rice	0.7	8.6	0.2	90.0		0.5	7.1	0.2	88.7	0.4	1,754
Wild rice:											
Whole grain	9.9	13.7	0.9	73.7	1.2	1.6	....	....	....	....	.....
Parched	9.6	13.0	0.9	74.0	1.1	1.4	10.1	0.8	70.4	1.1	1,565
Kafir corn:											
Flour	10.7	6.6	3.5	69.5	1.2	2.2	5.1	3.4	68.3	1.7	1,452
Meal	10.1	11.2	0.5	68.1	2.0	2.1	8.7	0.5	67.8	1.6	1,436
Bread, entire wheat	38.4	9.7	0.9	48.5	1.2	1.3	8.0	0.8	46.7	1.0	1,079
Bread, Graham	35.7	8.9	1.8	51.0	1.1	1.5	6.8	1.6	47.4	1.1	1,081
Bread, white	35.3	9.2	1.3	52.6	0.5	1.1	8.1	1.2	52.0	0.8	1,203
Crackers	6.8	10.7	8.8	71.4	0.5	1.8	9.1	7.9	70.6	1.4	1,915
Macaroni	10.3	13.4	0.9	74.1		1.3	11.6	0.8	72.2	1.0	1,660
Beans, dried	12.6	22.5	1.8	55.2	4.4	3.5	17.6	1.6	57.8	2.6	1,434
Peas, dried	9.5	24.6	1.0	57.5	4.5	2.9	19.2	0.9	60.1	2.2	1,457
Potatoes, raw	78.3	2.2	0.1	18.0	0.4	1.0	1.6	0.1	18.2	0.8	360
Beefsteak	66.0	20.3	13.6	....	....	1.1	19.9	12.9	....	0.8	960

cleaning, milling, and otherwise manipulating the grains take little from them and add nothing to them, though such processes may and do modify materially the appearance, texture, and flavor.

When digestible nutrients are considered, the differences between the various cereal preparations are not more marked, and, as may be seen from the data in Table 1, the relative rank of the cereals is about the same as when they are compared on the basis of total nutrients. Thus, the oat foods contain the largest amounts of digestible protein and fat and their fuel value is highest. The wheat preparations, either plain or malted, rank next to the oats as regards digestible protein. The barley, corn, and rice preparations are much alike, both in the amounts of digestible nutrients furnished and in the available energy which they yield. The table also shows that the quantities of nutrients digested from the breakfast cereals correspond very closely to the quantities digested in other cereal preparations from the same grains. Thus, wheat breakfast foods and macaroni supply about equal amounts of digestible material, as do also corn mush and corn bread. The so-called partially digested or ready-to-eat cereals seem to supply no more digestible material than the plain grains when well cooked.

Owing to the differences in the amount of water contained in the different classes of cereal foods, it is perhaps fairest to compare the uncooked breakfast cereals with flours and meals, and the ready-to-eat goods with such dry materials as macaroni and crackers, though these latter on an average contain a trifle less water than the breakfast foods. On such a basis it will be seen that hominy seems to contain a little more digestible protein and a little less digestible carbohydrates than corn meal, the differences being due perhaps in part to the method of preparation and in part to the kind of corn used. The wheat flours contain on an average more digestible protein and digestible carbohydrates than the wheat breakfast foods. Crackers are poorer in digestible protein and carbohydrates than the comparable breakfast foods, but usually contain so much added fat that their total fuel value is higher. Macaroni is very like wheat breakfast foods in composition and food value.

TABLE II. — COEFFICIENTS OF DIGESTIBILITY OF DIFFERENT CLASSES OF CEREAL FOODS AND A FEW OTHER FOODS.

Kind of Food.	Protein.	Fat.	Carbohydrates.	Energy.
Cereal Breakfast Foods.	Per Ct.	Per Ct.	Per Ct.	Per Ct.
Oat products	77.9	*90.0	97.0	87.8
Wheat products, malted, ready to eat	75.4	*90.0	91.4	84.7
Wheat products, crumbed and malted, ready to eat	74.7	*90.0	90.0	83.6
Wheat products, uncooked, decorticated	80.9	*90.0	95.6	89.3
Wheat products, undecorticated	72.7	*90.0	91.0	83.3
Wheat products, rolled, partially cooked	83.1	*90.0	93.1	86.1
Rye products	†77.8	*90.0	†93.8	†86.4
Barley products	†77.8	*90.0	†93.8	†86.4
Buckwheat products	†77.8	*90.0	†93.8	†86.4
Corn products	73.9	*90.0	98.9	94.5
Rice products	83.0	*90.0	98.0	90.0
Wild rice products	†77.8	*90.0	†93.8	†86.4
Kafir corn products	†77.8	*90.0	†93.8	†86.4
Other Foods for Comparison.				
Bread, white	88.0	*90.0	98.0	92.0
Bread, Graham	76.0	*90.0	91.0	83.0
Bread, entire-wheat	82.0	*90.0	94.0	87.0
Macaroni	86.8	*90.0	97.4	92.1
Legumes	78.0	*90.0	97.0	86.0
Potatoes	73.0	*90.0	99.0	91.0
Beefsteak	98.0	98.0	...	....

* Estimated value. † Calculated on the basis of available data.

A large number of experiments with healthy men, to learn how thoroughly cereal breakfast foods are digested, have been carried out at the Connecticut (Storrs), Maine, and Minnesota agricultural experiment stations, in the majority of which the cereals were eaten with cream and a little sugar and the digestibility of the cereal breakfast food alone was computed by the usual methods from the values obtained from the ration as a whole. In other tests the cereals formed a fair proportion of a simple mixed diet, which is, of course, the way they are usually served. The "ready-to-eat" goods were served without further cooking. The others were thoroughly cooked.

Table 2 summarizes the results of the digestion experiments with cereal breakfast foods, similar data regarding some other food products being included for the purpose of comparison.

The range in the digestibility of protein was greater than with carbohydrates or energy. As regards the protein of cereal breakfast foods, the highest coefficient of digestibility, 83.1 per cent, was noted with rolled-wheat products partially cooked—i.e., cooked at the factory—and the lowest coefficient, 72.7, with undecorticated wheat products. The cereal breakfast foods, in general, like entire-wheat and Graham bread, are somewhat less digestible than white bread.

In a series of digestion experiments made at the Maine Experiment Station rolled oats, rolled wheat, granulated corn meal, hominy, and some of the common commercial brands of specially prepared breakfast foods were studied. The ready-to-eat goods were used as manufactured, while the rolled wheat, oats, and other such brands were thoroughly cooked in a double boiler. In general, about 90 per cent or over of the organic matter was assimilated when the cereals were eaten in a mixed diet containing bread and meat and in a simple diet of cereal, cream, and sugar, and also when the results were computed for the cereal breakfast food alone. In the case of the mixed diet the highest coefficient of digestibility of protein, 93.2, was noticed with rolled wheat, and the lowest, 88.9 per cent, with hominy. In the case of the simple diet, the range in the digestibility of protein was from 82.3 per cent with granulated corn meal to 91.6 per cent with rolled wheat. Considering the results as computed for the cereal breakfast foods alone, the lowest value, 57.7 per cent digestibility of protein, was noted with a specially prepared whole-wheat product, and the highest value, 85 per cent, with rolled oats. The availability of energy was high in all cases. It was not far from 90 to 93 per cent with the mixed diet. With the simple diet the range was somewhat greater, namely, from 91.1 per cent with a specially malted cereal to 96.4 per cent with hominy. With cereals alone the lowest value was 84.1 per cent available energy with a specially prepared whole-wheat cereal, and the highest value, 94.4 per cent, with hominy.

In these tests corn products with a mixed diet and with a simple diet made a favorable showing as regards both total organic matter and energy, but were inferior to the other goods in respect to the digestibility of protein. The conclusion was reached that if the cereal breakfast foods, especially those made from oats, corn, and wheat, are rated in proportion to the digestibility of their protein when used with a mixed diet, rolled wheat must be placed first and the corn products last. When the digestibility of the cereals alone was calculated, rolled wheat ranked first, not only in digestibility of the total organic matter, but also with respect to the protein. The rolled oats ranked next, and the corn preparations and a specially prepared whole-wheat product the lowest of all.

CISTERN CLEANERS IN THE DELTA.*

By RAYMOND S. SPEARS.

IN the bottom lands of the Mississippi Delta Basin, particularly in the region south of the fork of the Ohio, the water used by the plantation people and villagers comes principally from rain-catching tanks and cisterns. In a few places, such as Rosedale, Miss., Lake Providence, La., etc., there are artesian wells which furnish water to the people in the vicinity, but even in such towns by far the greater number of the residents are supplied with water caught from the roofs of the buildings.

There are two types of rain-water receptacles, the underground and the above-ground. The latter are usually called tanks, and are made of either wood or iron. The underground cisterns are generally built of brick and cement. Either will hold anywhere from 500 to 10,000 gallons of water.

Thousands of plantations and dwellings depend entirely on cistern or tank water for cooking, washing, and drinking. Comparatively few use the bottled distilled water which is sold in the cities. Well water would be full of deadly germs from the vegetable silt soil, and only cabin boaters drink river water.

Because of the importance of cistern water to the people, much effort is expended in keeping the water "sweet." Hence the violations of the regulations in regard to "screening" or covering the cisterns in New Orleans. To screen a cistern "keeps out the air" and soon the water smells and tastes of decaying vegetable matter, not to mention the mosquitoes and other insects which, failing to find an exit, have been drowned in it.

Because the eave troughs catch much dust and many leaves, the bottoms of the cisterns and tanks are soon covered with decaying matter. During the winter, the water is sufficiently cold to prevent the consumers noticing much taste to the water, but as soon as warm weather comes, the pumps bring up water that "fairly smokes," as the Delta saying is. Then it becomes imperative to clean the cisterns, and this fact has led to the development of a class of itinerants similar to umbrella menders, scissor grinders, and junk buyers. They are called "cistern cleaners."

Emptying the cisterns and tanks in order to clean them is not to be thought of, because rain water is so valuable. About forty patents have been taken out for cistern-cleaning apparatus, including power machines and bottom pumps which do not require the pumping out of the water.

The implement used by the itinerant cistern cleaner is a bucket on the end of a 25-foot five-part jointed pole. The bucket is thrust to the bottom of the cistern or tank, and an iron rod on the outside of the bucket is forced up by contact with the bottom of the cistern. This rod lifts a cork out of a hole in the top of the bucket and the air bubbles out. When the air comes out, a valve on the bottom of the bucket rises, and the water on the floor of the cistern rushes into the bucket. As the sediment is what makes most of the trouble in cistern water, when the bottom layer of water, containing the leaves and other dirt, has been removed, the cistern is regarded as "cleaned."

For this work, the cistern cleaners receive $5 per tank. To clean a cistern thoroughly in this manner requires two hours at the most. Many cistern cleaners, however, do not do their work thoroughly and they have contrived a way to skimp the labor under the eyes of the one who is watching them.

In hot weather, the first bucketful of water that comes up is fearfully odorous. Many a cistern cleaner has died from malaria and other diseases to which his work has rendered him liable. After two or three tubfuls have been drawn, the water becomes fresher, and after a time that drawn from the bottom is as sweet as that at the top. Then the cistern cleaner is ready to clean another tank, or goes in search of work elsewhere. Some plantations have six or eight cisterns. To beat the plantation owner, the cistern cleaner instead of taking all of the dirty water from the bottom of the tank, after drawing a few bucketfuls, strikes the valve plunger of the bucket against the side of the cistern before it gets to the bottom. This is not difficult to do in the brick-and-cement cisterns, owing to their shape. The underground cistern is shaped like a bottle with two necks, one at the top and one at the bottom. Some of these cisterns are 25 feet deep, and 8 feet in diameter. At the bottom the sediment accumulates in the neck there, and the cistern cleaner is supposed to draw the water from the deepest place until the water is clear and sweet. Instead of doing this, he strikes the valve plunger against the shoulder, five or six feet from the bottom, and the water comes up as pure as though the sediment had all been removed. The cistern cleaner, in this way, contrives to reduce his labors by about two-thirds.

A cistern cleaner told the writer of this article that he cleaned cisterns from central Indiana to Plaquemine, La. "The Italians have killed the business around New Orleans. They do it for a dollar and work like horses—ain't up to white men's tricks. They make $5 a day. I make $20."

The plantation owners do not discover the swindle perpetrated on them for years, unless a cistern springs a leak, or one runs dry. Two years ago, before the artesian well was driven in Lake Providence, La., many of the cisterns "went dry." It was then found that a cistern cleaner who had "worked the town" had not removed a quarter of the sediment from the cisterns he cleaned.

This year is a full harvest season for cistern cleaners. Scores of them are traveling from plantation to plantation throughout the valley of the Mississippi, scorning yellow fever and the heat. Never were there so many cisterns to clean before, for every one is frightened into "cleaning up the place." Every cistern is "ready money" from the viewpoint of the cleaners.

First of all, the cistern cleaner shows the owner that a tank needs cleaning. He draws up a bucketful of water from the bottom and pours it out on the ground. No matter if the cistern has been cleaned within a week, the water gives forth a vile and frightening odor. "That other man didn't half do his work," the plantation owner is told.

Having the work to do, the ordinary cistern cleaner works a while, and then, at a favorable opportunity, works his little side-hitting trick, receives his money and goes on to the next plantation. Some of the itinerants hire a negro to carry the 30-pound cleaner, and give the cistern owner a printed receipt for "keeping the water pure." All of them rejoice in a "fever scare," because at such times "business is on the boom."

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

SUBMARINE COAL MINING.

CONSUL-GENERAL W. R. HALLOWAY, writing from Halifax, says that there are now in Cape Breton six collieries working under water.

The largest is the Princess or Sydney pit in Cape Breton Island. This colliery was the first in North America to mine coal from beneath the bed of the Atlantic Ocean. The seam of coal averages between 5½ and 6 feet thick, of best quality. The angle of dip or inclination seaward is 5 degrees, or about 1 foot vertical in 12 horizontal. The working of the "whole coal" under the sea by the bore-and-pillar system was commenced in 1877, under an overhead cover at the shore line of 690 feet of solid measures, although part of the workings driven to the rise under Sydney harbor was operated under a cover of 500 feet or less.

The present workings are distant from the shore line 5,800 feet to the dip. At this point the overhead cover is 1,140 feet in thickness of strata, with 33 to 40 feet depth of water above it. The undersea workings in the whole coal cover 1,620 acres. No sea water has yet found its way into the workings as a result of removing the pillars. A feeder of a few gallons of water per minute was encountered in some whole-coal workings driven to the rise, as also at the face of the water levels driven in the direction of the outcrop to the south, but this water evidently followed the seam of coal downward from its outcrop under the waters of the harbor. There has been no water known to come from overhead across the measures.

This immunity from overhead leaks from the ocean is probably due to the presence in the superincumbent strata of twelve beds of fire clay or underclay of a total thickness of 39 feet, as well as to the numerous beds of shale. The subsidence of the overhead strata caused by the removal of a bed of coal 6 feet in thickness would probably under these conditions soon choke itself, so that there would be no further actual motion

or settling of the strata for more than, say, 100 feet upward. Above that point the elasticity of the beds of shale and fire clay mentioned would prevent any rupture. Fire clay when brought into contact with water soon forms a soft clay resembling putty and impervious to water. Out of the submarine area there has already been taken some 5,250,000 tons of coal from the main seam, while the company has also commenced the working of another and thicker seam in the same area, from which in all likelihood they will secure as much coal as has already been taken.

CHAIN-MAKING MACHINERY.*

By EMILE LELONG (Couillet).

IT would serve no useful purpose to retrace the history of the many complicated and costly processes of chain making by machinery. All these processes were of short existence, and possessed but slight interest. In order to clearly appreciate the advantages gained by the Lelong system, it is merely necessary briefly to describe the usual methods of chain making. The chain maker, helped by one or more strikers, first cuts off the bars of iron in lengths a little longer than the ultimate length of a link. The bar is then heated, and bent on the anvil to the form of a U. The ends of the U are again reheated and hammered to the form required for welding. They are brought to a welding

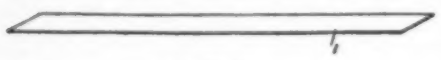

FIG. 1.

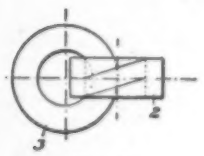

FIG. 2.

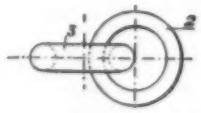

FIG. 3.

heat and welded by hammer on the anvil. The chain is then made to standard by means of stamps and dies, by hand. The slowness and imperfection of the system are clear, and many attempts have been made to improve the conditions and to avoid the danger resulting from scarf welding, which constitutes a weak point in every link. In 1881, Mr. Oury cut from rolled bars of cruciform section links of chain, but the process was complicated and soon abandoned. The links so formed were coupled together by scarf-welded links. In 1816, Samuel Brown and Philip Thomas patented a system of making spiral links. Oury utilized this invention, and made his coupling links exactly like an open key ring. After coupling, by welding, he was enabled to make chains of any length. In 1889, Arthur George Dufaud Crawshay, of Middlesex, patented a machine for making open spirals destined to form links. The links were made of an oval form in a machine, and, after interlocking with finished links, were welded in dies of the necessary shape. A Belgian company made a machine for interlacing the open spiral links with finished links and finishing the same. The process was long and costly, requiring considerable labor to attend to the various machines. These were: (*a*) Machine for preparing spirals; (*b*) interlacing and forging machines; (*c*) machine for bending the links oval; (*d*) various furnaces for above machines. The above show that the chain-making operations have not been reduced in number, but only aided by a series of machines.

In order to remove the disadvantages and to avoid the cost and waste of time resulting from the preparation of a helix, the successive convolutions of which are opened, the heating and subsequent passing through and linking with the previous link, the author forms the links, not by the aid of a helix or spiral prepared in advance, but by a simple bar of metal cut to the required length. The bar, heated and introduced into the machine, forms at once a link of spiral form linked to the preceding link. This rough link is formed on the anvil of the machine, welded, made to standard, and bent oval without removing from the machine and without reheating. The process of manufacture is as follows: A bar (Fig. 1) of the calculated dimensions to form a link is prepared. The bar is heated and introduced into a machine which forms, in one operation, the rough link 2, which at the same time is linked to the finished link 3, as shown by Figs. 2 and 3. In order that the small bar may be at once and in a single operation formed into a finished ring, passing through a ring previously made, a machine is employed, which consists essentially of a cap (4)—Figs. 4 and 5. This cap is placed on the anvil (6) of a forging machine inclosing two rollers, one of which

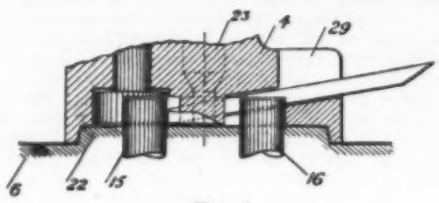

FIG. 4.

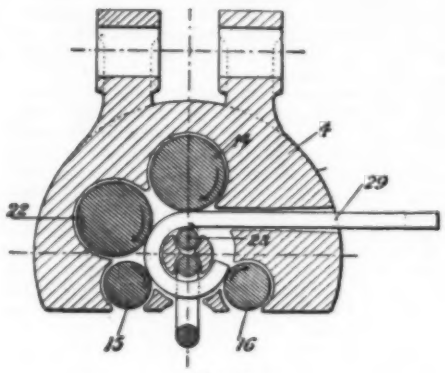

FIG. 5.

(23) acts on the interior of the link being formed; the other (22) acts as a guide on the outside of this same link. The cap is provided on the face, which rests on the anvil, with recesses, in which are rollers (14, 15, 16) which project from the face of the anvil. The cap is also provided with an inclined passage (29) leading between the rollers (14 and 23) into a circular passage formed by the cap and the different rollers. Figs. 6 and 7 show how the bar is wound.

The cap can be raised or turned aside on a hinge to permit of the ring, formed on the anvil between the rollers (14, 15, 16), being welded and stamped. After they have been used in forming the link, the rollers (14, 15, 16) projecting above the anvil can be brought nearer to or farther from the work by the attendant, so as to enable him to make either a continuous chain or separate links as required.

Two attendants are required to work the machine, one to introduce the bar to be made into a link and the other to regulate the forging machine and give the link an oval form. A machine with a steam hammer for the manufacture of chains from 8 millimeters to 26 millimeters diameter is illustrated below—Figs. 8 and 9. Any suitable hammer, such as a steam hammer, a spring hammer, or a pneumatic hammer, may

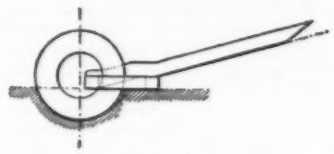

FIG. 6.

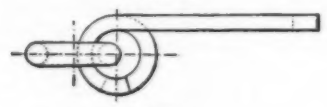

FIG. 7.

be employed. The machine consists of a frame in three parts: the base (5) on which the anvil (6) rests, and which incloses the gearing of a part of the spiral-forming mechanism; a bracket (7) for supporting a forging hammer, an extension (9) of the base with outer bearing of driving shaft (10), with flywheel (11) and driving pulleys (12 and 13). The gearing inclosed in the base drives three vertical rollers (14, 15, and 16—Fig. 5) which pass through openings provided in the anvil.

The rollers can be operated according to the stages of working either by counter-weight (17), or by a hand lever (18), in order to bring them near to or farther from the center of the anvil as required. For this purpose they are connected together by a system of links (19, 20, and 21), which cause similar movements of the three rollers following the movements of the guides, which slide in openings provided in the upper part of the base. The cap (4) is held in position on the anvil, and incloses two rollers (22, 23), one of which acts on the interior of the link to be formed, and the other serves as a guide for the formation of the spiral.

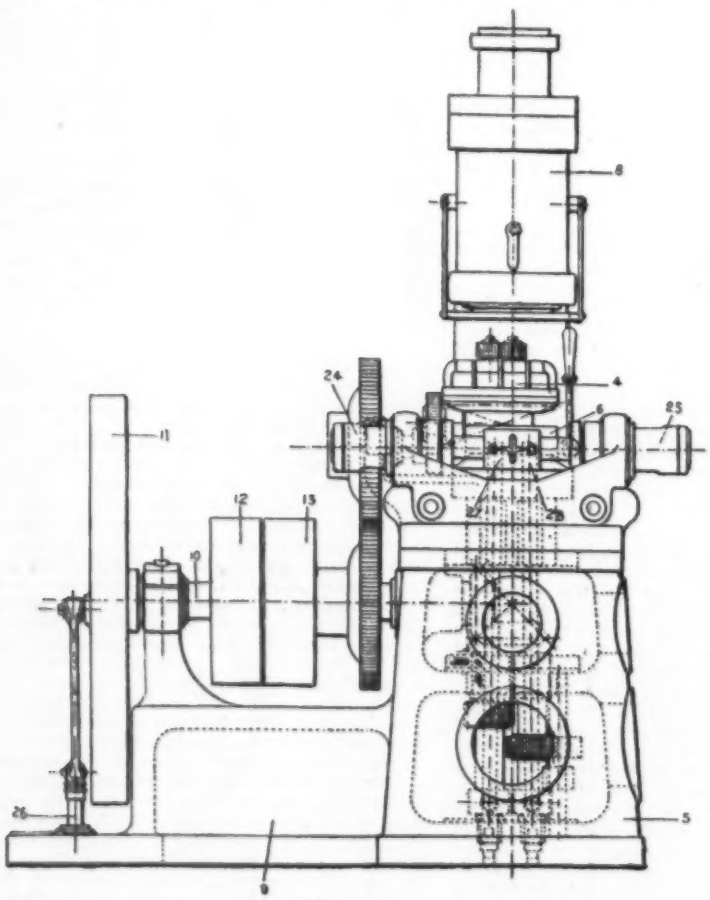

FIG. 8.

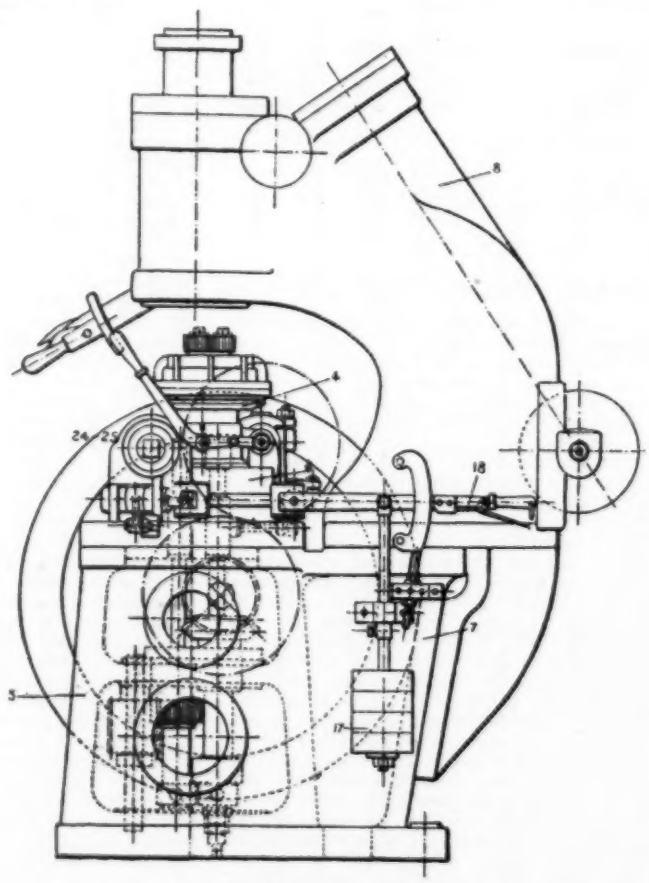

FIG. 9.

* Iron and Steel Institute.

Two hydraulic cylinders are fixed to the part bolted to the top of the base, and are worked, by means of a small accumulator, by a pressure pump (26). The pistons of these cylinders are provided with heads, in the form of dies (27, 28) of the required shape to hold the links, when made, in a suitable position, and to ovalize the links to the required size. Motion is imparted to the rollers inclosed in the cap by spur wheels, and their rotary motion is correlated to that of the rollers which pass through the anvil. When the cap is raised to allow forging, a special mechanism retains the ring link on the anvil; this is necessary, as the link might otherwise stick in the passage and be removed with the cap.

After this the machine is set in motion, and a heated bar is introduced into the passage (29—Figs. 4 and 5) and in a fraction of a second it is moved forward, bent, and caused to pass through the preceding link so as to form the required ring link. The cap is moved on a hinge (Fig. 11) and a few strokes of the power hammer suffice, not only to forge the ring, but to stamp it to a round form. The chain is then displaced the length of a link, and is bent oval by the hydraulic piston heads, and held in position by the passing through of a new link, the manufacture of which is proceeded with forthwith.

The fruitless attempts to suppress the welds in the links of a chain have already been alluded to. In no process where the ring is formed by rolling a bar into a helix has this been satisfactorily realized, while the weld is distributed over the whole contour instead of being localized at a single point. It is clear that chains welded in this manner cannot be termed weldless chains. This weld gives, however, considerable security when the surfaces brought together are clean, from the method of rolling, the energetic forging on the anvil under the rapid action of the power hammer working on the whole surface of the weld and the link, insure superior quality in the product. Experience has shown that, by reason of the bars being shorter and only requiring careful heat treatment at the ends, the heating is easier and more regular than when the whole length of bars for making links by successive convolutions have to be heated. By studying the various conditions of working, not only marine chains, but also small chains for pulley blocks and for the ordinary requirements of trade, can be made with the machine.

Figs. 12, 13, and 14 show a round bar—this section may be square or any other form—used for forming a link to pass through the link already manufactured, according to the second method, on the anvil of the machine.

Figs. 15 and 16 show the successive operations of making a chain link by the second method by using a square bar. *A* is the bent link; *B* the link welded and forged; *C* the link ovalized and finished. This description clearly indicates that two skillful attendants can turn out a considerable number with a machine of this construction. The framing is of cast steel, and very massive.

The framing weighs about 50 per cent of the total weight—about 3½ tons—of the machine. All the machine parts are of steel, the bearings of hard bronze, and the gearing wheels are machine-cut. The power hammer, the driving pulleys, and the flywheel are of cast iron. The working parts are all accessible for fitting and repairs, and the machine only occupies a space of 3 feet 6 inches by 5 feet 2 inches. The accumulator is a horizontal hydraulic cylinder, and only

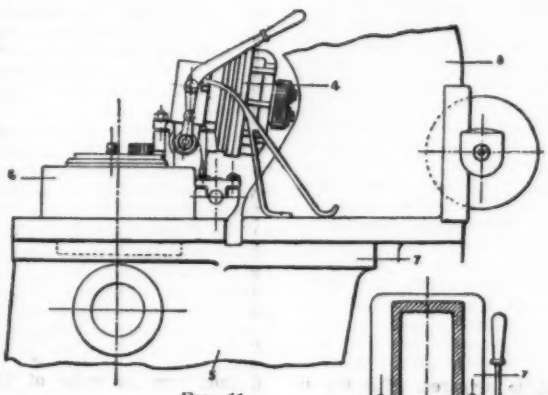

FIG. 11.

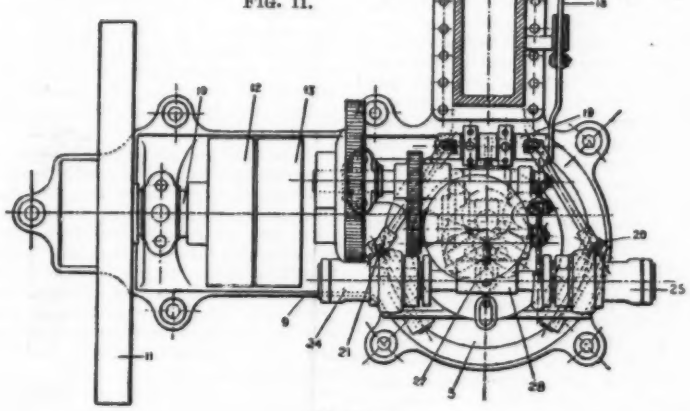

FIG. 10.

are at the requisite temperature, and are worked rapidly.

It must be mentioned, however, that chains formed of links made by the multiple superposing of a bar or sheet of metal rolled into a spiral or helix forms have not yet received the sanction of practice; and the effects of wear have not yet been determined. Many chain manufacturers hesitate to abandon established methods of chain making and to embark their capital in new machinery, and their hesitation is, to a certain extent, justifiable. They will disappear when a machine is found to manufacture not only links of the type actually produced by all chain makers, and of an improved quality, but also chains.

The Lelong machine can effect these operations economically. The machine described makes, with the same facility, links of all dimensions, of any length or section, and of the desired convolution. If, therefore, for any special reason a chain maker employing the Lelong machine desires not to produce spiral links as described, he can, by diminishing the length of the bar, by increasing the section to that of the link to be made, and by scarfing the ends, manufacture chains by machinery, in a single heat, and by using only one machine; the links of such chains are made by a single convolution of the bar and are of the type accepted in all countries for marine purposes.

The great simplicity and rapidity of manufacture, together with the low cost, are not the only advantages of the machine when making chain of the ordinary type. The length and section of the scarfing of the ends is carefully studied, and assures a large welded surface. The rapid contact of the surfaces to be welded, which are at equal temperatures resulting occupies a space of 1 foot 7 inches by 4 feet 11 inches. The small space occupied by the machine permits of its erection on board repair ships.

Hand-made chains ⅝ inch diameter, costing £12 10s. per metric ton, can be made by this method for £8 10s. This represents an economy of £4 per ton in favor of machine-made chains.

In an interesting paper read before the Society of Belgian Engineers, Eugène François states that the chain-maker requires one helper for chains from ⅝ inch diameter, two from 1⅜ inch diameter, and three from 1⅞ inch and above. While the Lelong machine produces, according to the diameter of the chain to be made, a number of links which diminishes only to a slight extent with the increase in diameter of the chain, the author states, in the above-mentioned report, that a chain-maker with his helpers can make by hand thirteen links of ¾-inch, or 6½ links of 1½-inch chain in one hour. The Lelong machine can make from 100 to 120 links of ⅝-inch chain per hour.

In making chains of larger dimensions the economy would be even more marked. Ordinary chains are quoted in Belgium at £13 10s. to £14, and in France at £13 to £13 10s., and calibrated chains at £15 to £16 per metric ton. The introduction of chain-making machinery is of considerable interest, owing to the large quantity of chain employed; America produces, for her home consumption alone, 50,000 tons yearly.

Numerous tests of chain manufactured by the new process of spiral links, the successive convolutions of which are united or continuous, have shown a breaking strength equal to 80 per cent of that of the metal employed. In other words, with the same material, chains made by the new process are 20 to 25 per cent stronger than the best chains manufactured by the usual methods.

In order to obtain the same strength, iron of a lower grade may be employed. The increasing demand for steel has reduced the production of the special brands of iron for chain-making, and Swedish iron at a high price has to be used. On the other hand, steel works now produce extra mild steel, which can with perfect safety be employed for chain-making by machinery, as described. The use of these steels for chains made by hand would not give the necessary security. Extra

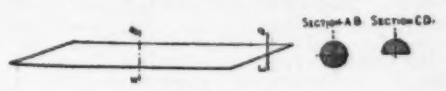

FIG. 12.

mild steel has all the physical properties of Swedish iron, and its cost differs little from that of best iron.—Engineer.

THE VITRIOLIZING OF WHEAT.

As is well known, wheat smut is a cryptogamous disease that annually causes incalculable damage, says M. Louis Monet in the Revue Agricole du Sud-Ouest. The invisible parasite penetrates into the ovarium, where it multiplies, and soon fills the cavity with a blackish powder of a somewhat disagreeable odor. It is noteworthy that smutty wheat has often as fine an appearance as healthy wheat, but it is lighter and bursts under the pressure of the fingers. For a long time, liming the seed was proposed as a remedy, and

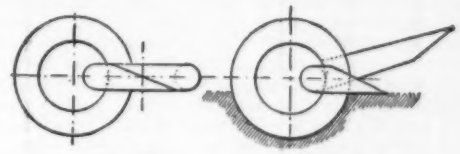

FIG. 13. FIG. 14.

it was steeped for nearly half a day in a one per cent solution of "vitriol," and stirred from time to time.

Several years ago smut caused much damage in the Department of Isère, France, and the crops of one of the farmers were diseased to the extent of twenty per cent. While sound wheat was selling at 20 francs per 100 kilogrammes, affected wheat went at 16 francs. The following are comparative figures: A hectare of good wheat producing about 2,000 kilogrammes at 20 francs, 400 francs; the crop containing 20 per cent of damaged wheat being 1,600 kilogrammes per hectare at 16 francs, 256 francs; a loss of 144 francs, which seriously diminished the income from the soil. To avoid this heavy loss it is merely necessary to vitriolize wheat with cupric sulphate and not with ferric sulphate.

In our neighborhood, cupric sulphate, which is blue,

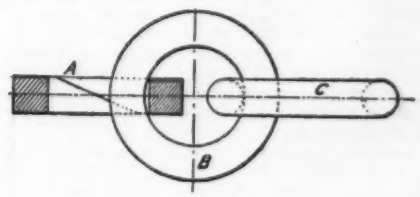

FIG. 15.

and ferric sulphate, which is green, are designated indiscriminately as "vitriol." Many farmers believe the products are equally efficacious, and use ferric sulphate exclusively, because it is cheaper, a useless economy of a few centimes per hectare when it may result in a loss of more than 100 francs.

The process of soaking the wheat in a two per cent solution of cupric sulphate would perhaps be better, for the grain is thereby saturated, but troughs would be necessary, and the manipulation is somewhat difficult. The process of sprinkling, which is usually adopted, is very good, provided it is done carefully. In this case the percentage of cupric sulphate may be greater, as the seed is not to remain in the solution. My tests have shown that wheat sprinkled with a solution of

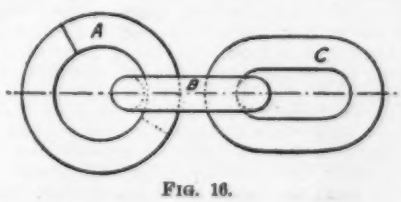

FIG. 16.

five per cent germinates very well. When this percentage is exceeded, however, germination proceeds more slowly, and if it is made still higher, it may destroy the germinating power.

The operation is as follows: For 100 kilogrammes of wheat, 200 grammes of cupric sulphate are dissolved in 5 liters of boiling water; ten minutes at most are allowed for cooling. The solution cold is as good as when hot; emulsionizing it too hot may prevent germination. The mass is watered and turned over with the shovel several times. The proportion of 3½ liters

to 100 kilos, which is usually employed, is not sufficient. It is necessary to make sure that the spores (black dust) that propagate the disease, are not lodged in the cleft of the grain; if the liquid is not in sufficient quantity to penetrate thoroughly, the spores are not destroyed, and the wheat is not saved.

To obviate the excess of moisture that inconveniences the sower by causing grains to adhere to his hand, it suffices to prepare the seed twenty-four hours before sowing, thus giving it time to drain.

OPTICAL ILLUSIONS.

OPTICAL illusions often exhibit this peculiarity, that they cannot be converted into correct perceptions by better knowledge and the exercise of reason. We often know perfectly well that we are the victims of an illusion, and even know, perhaps, how it is produced, yet all this superior wisdom avails us nothing. The senses and the reviewing mind cannot escape the deception, in which our abashed reason is compelled to leave us.

Indeed, our reason is not only unable to guard us against such illusions of the senses, but in some cases it appears to be the direct cause of them.

A very simple and striking example of this can be observed at theaters where, between the acts, advertisements and pictures are projected by a stereopticon on a white screen that replaces the usual curtain. At the end of the intermission, usually, the opaque-painted curtain is slowly lowered in front of the screen. As the curtain encroaches on the field of projection, the upper part of the picture falls upon it, while the lower part remains visible on the white screen. The involuntary impression upon the spectator is that the upper part of the picture, also, is still formed on the white screen and not on the painted curtain, but the latter appears to be full of holes, through which the picture on the screen behind is seen. The illusion is especially strong when the curtain is painted with arabesques in alternate light and dark colors. In this case the curtain appears to be made of fine lace, through which the advertisement on the screen is distinctly visible. The illusion may persist even after the painted opaque curtain has been entirely lowered.

But a spectator who happens to enter the theater at this moment never falls victim to such an illusion. He sees things as they are, and observes that the advertisement is projected on a painted curtain, and is somewhat indistinct and illegible for that very reason.

Here, therefore, the uninitiated person is not deceived, while the spectator who has seen the advertisement first projected on the screen, and afterward intercepted by the curtain lowered in front of it, cannot shake off the illusion. His reason tells him that the picture is on the white screen. Consequently, as the picture remains visible, though imperfectly, after the descent of the curtain, it "stands to reason" that the curtain is perforated. Here our wise understanding leads us into error; and although we immediately recognize both the existence and the cause of the error, we cannot by any effort of the mind dispel the illusion that the mind itself has created. The frequency of comments like "How queer that looks!" proves that the illusion is common to most spectators.

Disagreeable as is the knowledge that our organs of sense are so imperfect that they frequently give us false testimony concerning the world about us, it is still more discouraging to learn that our higher critical faculties are also liable to error, and that they even misinterpret the correct perceptions of our senses. In such cases we have to do with illusions of reason, rather than of sense. This distinction must be borne in mind in order to enable us to acquire a better understanding of these peculiar phenomena.

Illusions caused by the projection of images may affect the ear as well as the eye. When we hear a gramophone repeating a comic song with piano accompaniment, for example, we usually refer song and accompaniment to the same point in space, the disk or the horn of the gramophone. To no auditor, I think, would the song seem to come from one part of the room and the piano accompaniment from another. Even when the gramophone is concealed behind a screen, both musical impressions are generally referred to a common origin.

But the effect is very different if the moving picture of the singer, reproducing every gesture and facial expression, is projected on the screen synchronously with the gramophone performance. Unless the kinematographic representation is very poor, there is soon created the illusion that the song actually issues from the moving lips of the projected image, while the subdued piano accompaniment seems to come from a point far behind the screen and, perhaps, far to one side.

Thus we introduce the element of space into our auditory perceptions, although we know very well that the sounds which we distribute between two points separated by a considerable distance really come from a single point, the needle of the gramophone. Though neither the ear nor the eye, alone, would have been deceived, an illusion is produced by their simultaneous activity. But here again the error is due, not to the eye or the ear, but to the intermeddling of the reason, which argues that the song must issue from the lips which are seen moving exactly in the manner required to produce the successive sounds. This is, therefore, another case of illusion of the reason.

This illusion involves something that may be called stereoscopic audition Just as the eyes combine two pictures, which appear flat when viewed separately, into a solid image of three dimensions, so here the ear, which of itself does not perceive tone-pictures as objects possessing extension or solidarity, combines them with the other tone-pictures (so to speak) which the eye sees in the moving lips, and thus introduces the third dimension, and gives rise to the illusion that sounds of different qualities emanate from different points of space.

I do not absolutely deny that a gramophone can produce something of this stereoscopic effect, even without the misleading testimony of the eyes, the song and the accompaniment appearing to come from different directions, as, in fact, they did come when the "record" was made. But even the most perfect record cannot of itself separate the singer and the piano as widely as is done by the combination of the kinematograph picture with the sounds of the gramophone.

In ventriloquism, also, the eye has a great deal to do with the illusion. We see a puppet's mouth open and shut and its hands make gestures appropriate to the words that we hear at the same time. As the ventriloquist's lips, throat, and chest remain apparently motionless, we involuntarily conclude that the words are uttered by the puppet, to the mouth of which we refer the sound the more readily, as the ability of the ear to determine the place of origin of sounds is very limited.

Moving pictures may, however, produce illusions which are conditional, apparently, neither by defects in perception nor by errors in interpretation, and which we are, at first, inclined to lay to the charge of the kinematograph itself, improbable though it may seem that so purely mechanical an apparatus can err either in taking or in projecting the pictures.

Last November, two days after the ceremonial entry of the King of Spain into Berlin, the Winter Garden exhibited moving pictures of the little procession—a detachment of cuirassiers, then the carriages containing the royalties and their suites, and finally another troop of cavalry. The reproduction was excellent and very realistic with the exception of one astonishing detail—while the carriages moved forward, their wheels turned backward, as if they were on the point of retreating, with their axles, and letting the bodies of the vehicles fall to the ground. I was so startled by this phenomenon that, on leaving the theater, I looked hard at the wheels of the cabs in the street to see how they rotated. I found, of course, that they all turned forward—that is, the top of the wheel moved in the same direction as the carriage. I should add that the apparent backward rotation of the wheels in the moving pictures was conspicuously slow, very much slower, relatively, than the forward movement of the procession.

At first I could not find any possible explanation for this paradoxical appearance. It could not be due to accidental reversal of the film, for that would have reversed the entire procession, not merely the rotation of the wheels.

A few days afterward I saw another series of moving pictures of the same procession, and experienced a fresh surprise. In this case the wheels did not turn continuously in either direction, but except for an occasional small and unsteady rotary movement, backward or forward, remained as if stopped by brakes, while the carriages glided onward.

Although this effect appears, at first sight, even more peculiar and incomprehensible than the backward rotation of the wheels, it admits of an easy explanation which will also throw light on the other paradox.

In this explanation two things must be borne in mind. In the first place, a kinematograph film consists of a series of instantaneous photographs, taken at short and equal intervals of time. For the sake of example, we will assume that ten exposures are made in each second. In the second place, a carriage wheel contains a number of spokes, all exactly alike, so that one cannot be distinguished from another.

In most cases, probably, each spoke would occupy, in each picture, a position a little in advance of the position which it occupied in the picture taken one-tenth of a second before, and in the projected moving picture the wheel would therefore appear to roll forward normally. But suppose that a certain spoke—we may call it the first spoke—happens to be vertical in the first picture, and that the wheel turns just fast enough to bring the second spoke into the vertical position in the second picture. Then, if the speed of the wheel is maintained uniform, the third spoke will be vertical in the third picture, the fourth in the fourth picture, and so on. Therefore, as all the spokes look alike, the wheel in the moving kinematographic image on the screen will not appear to turn at all. Slight variations in the speed of the real wheel account for unsteadiness and oscillation of the wheel in the moving picture.

Now, if the average speed of the wheel is a little less than the speed assumed in the foregoing example, the second spoke will not have quite reached the vertical position when the second picture is taken, the third spoke will lag still farther behind the vertical in the third picture, and so on. As the spokes cannot be distinguished from each other, the impression made on the spectator is that the spoke first seen in a vertical position is moving toward the rear. Hence the whole wheel appears to rotate slowly backward.

Strictly speaking, therefore, the error lies neither in the apparatus nor in the eye, but entirely in the mind, which argues that the vertical, or nearly vertical, spoke must always be the very spoke that was first seen in that position, because there is no evidence to the contrary. For the fact that one spoke has been substituted for another is not perceived by the eye, and, consequently, not communicated to the brain. If the individual spokes were clearly differentiated by color or ornamentation, the illusion would not occur. This, therefore, is also an illusion of the reason.—From the German of Dr. Sehrwald in Prometheus.

CONTEMPORARY ELECTRICAL SCIENCE.*

SPONTANEOUS IONIZATION.—Madame Curie's supposition that radio-activity is due to an all-pervading radiation existing in the universe is now accepted in the converse sense that the radiation due to radio-active substances is present everywhere to a small extent, and accounts for the apparently spontaneous ionization of gases left to themselves in closed vessels. H. Geitel discusses the kinds of radiation which may be made to account for this spontaneous ionization. It may be due to traces of emanation contained in the gas itself, as is notably the case in subterranean vaults. The walls of the vessel play a prominent part. When they are incandescent they emit floods of ions, but even at ordinary temperatures many varieties of clay and other silicates emit ions. Even metals do so, and the recent experiments of Wood and Campbell have shown that this emission cannot be accounted for by superficial impurities. An analysis of the various radiations is necessary in order to decide the question as to whether all matter is radio-active. Thomson's observation that the alkali metals emit electrons not only when illuminated, but also in the dark, points toward a new phase of radio-activity.—H. Geitel, Verhandlungen, Deutsche Physikalische Gesellschaft, February 15, 1906.

DISCHARGE FROM HOT PLATINUM.—It is known that hydrogen has a marked power of increasing the negative leak from metals. O. W. Richardson proves that this is not an action in the interior of the platinum, due to the absorption of hydrogen, but a surface action. The method adopted was to measure the saturation current from the outside of a hot platinum tube to a surrounding cylinder in air, both when hydrogen was diffusing from the tube from inside and when it was not. The surrounding air would of course oxidize the hydrogen as fast as it came out, and thus keep the surface in a constant state, so that presumably any change in the leak would be due to the hydrogen and not to a change in the platinum surface. Even when hydrogen was allowed to diffuse through the tube at a rate equal to 2 cubic centimeters at 76 centimeters pressure per square centimeter of surface per minute, not the slightest change could be detected in the value of the negative leak. This result points strongly to the conclusion that the increase in the ionization observed in an atmosphere of hydrogen is not due to the presence of the hydrogen in the metal as hydrogen, but to some alteration it produces in the superficial regions of the metal. The hydrogen acts by producing a change in the wire, which takes a long time to complete itself. The results appear to be capable of explanation by assuming that the positively-charged hydrogen forms a double layer at the surface of the platinum which helps the electrons out. The positive leak, on the other hand, is directly proportional to the amount of hydrogen diffusing through.—O. W. Richardson, Proceedings of the Cambridge Philosophical Society, January 31, 1906.

COLORATION OF JEWELS BY RADIUM RAYS.—A. Miethe has found that an unexpectedly large number of jewels change their color under the influence of radium rays from strong preparations. It has been known for some time that glass is colored brown or violet, and the chlorides of potassium and sodium brown or yellow. Speaking generally, the color is changed most easily in the more transparent stones. The author used a preparation of 60 milligrammes of radium bromide. A colorless diamond from Borneo was colored a light yellow after eight days, and a decided lemon yellow after another eight days. On heating the diamond to 250 deg. C. the yellow color was diminished, but it could not be entirely got rid of even at a red heat. A colorless Brazil diamond showed no coloration. A peculiar behavior was shown by a light blue sapphire from Ceylon. After only two hours' exposure to radium bromide it showed a coloration, green at first, then light yellow, and after a few more hours, reddish yellow. After a fortnight it was dark yellow, or nearly chestnut. The color could be eliminated by heating, but the light yellow color always returned on cooling. Rubies show no change. Tinted tourmalines show little change, but a tourmaline having a pink color at one end acquired a red color at any section by exposure to radium rays, and a tourmaline having a green end acquired a dark green color at any section. Amethyst, blue topaz, and chrysoberyl show no change. —A. Miethe, Annalen der Physik, No. 3, 1906.

CAPACITY OF MICA CONDENSERS.—The differences in the value of the capacity of the same condenser observed in determinations made at different times (with different galvanometers) have given the impression that mica condensers are not available for measurements of high precision. The manufacturers of the best condensers guarantee an accuracy of only one-fourth of one per cent, and even this is not usually trusted by the purchaser. The reason for these differences is that with the method of measurement commonly employed the capacity value is dependent upon the period of the galvanometer. The condenser is charged or discharged through the galvanometer and remains in circuit with it during the whole period of the first throw. The gradual liberation of the absorbed charge produces a current which flows through the coil of the galvanometer the whole period of the throw. The longer this period the greater is the amount of the absorbed charge that affects the throw,

* Compiled by E. E. Fournier d'Albe in the Electrician.

and the greater is the value obtained for the capacity of the condenser. A. Zeleny has devised a special triple key which, with one tap, closes the condenser circuit through the galvanometer and opens it immediately afterward. He thus measures the "free-charge capacity" of the condenser, and finds it to be a very constant quantity, measurable within a maximum error of 0.01 per cent. He suggests defining all capacities as free-charge capacities.—A. Zeleny, Physical Review, February, 1906.

ELECTRICAL NOTES.

In comparing modern electric generating works with similar works equipped ten or fifteen years ago, one of the most striking features in the former is the increase in output of the generating units in the engine room and their relative decrease in size. This contrast is especially emphasized when steam turbo-electric generators are compared with those driven by slow-speed reciprocating engines, and it is now common practice to install three or four times the amount of power in a given size of engine room which was then possible. Again, in many of the early generating works small plants of, say, twenty-five to one hundred kilowatts were installed; these soon became too small, and their places are now filled by units occupying practically the same floor area, but of greatly increased power.

With the introduction of electrical driving of machine tools came also the high-speed tool steels, and these steels need above everything else a proper control over the cutting speeds on the work. An increase of the linear speed of the work before the point of the tool from two to four times that which had hitherto been possible, came into the shop about the same time that the electric motor appeared on the field, and naturally both elements demanded consideration together. In the upheaval caused by these steels much that was obsolete beside cutting speeds was brought to light. When it was attempted to use such steels at their highest speeds on machine tools of ordinary designs, those tools speedily developed structural weakness, made apparent by breaking down or by excessive vibration. The general line of metal-working machinery has had to be largely redesigned, not only made heavier, but changed entirely in important details in order that the machinist may avail himself of the highest speeds now possible.

In a lengthy article on atmospheric electricity, published in Prometheus, an engineer, Otto Nairz, makes some interesting computations regarding the energy-value of a bolt or flash of lighting 1 kilometer in length and lasting one-thousandth of a second, by imagining it, with Hertz, stored up in a storage battery. The result he summed up in the following comparative statements. According to the Berlin price for electric energy for illuminating purposes of 40 pfennigs (10 cents) per kilowatt hour we would obtain through the theoretic accumulation a gain of $700. The energy-value corresponds during 40 seconds to the entire electricity produced in Germany and during 2¼ minutes to the amount produced in Berlin alone. Furthermore we will be enabled to furnish for 1½ hours the power for the Berlin elevated and subway at the time of its greatest traffic or to feed an express car with a velocity of 200 kilometers per hour for the three hours' trip from Berlin to Frankfort, or finally to keep a single incandescent lamp of 32 standard candles lit for 8 years. Since, during a single thunderstorm, up to 1,000 flashes or bolts of lightning have often been counted and the one selected is not a very heavy one but merely of average strength, this simple calculation affords a striking example of the efficiency of Nature with regard to electricity.

A curious misconception in very elementary textbooks is as to the portion of an ordinary bar magnet which is the more highly magnetized. Examinees tell one *ad nauseam* that it is the ends which are so. Of course, it is near the ends that most external evidence is obtained of the bar being magnetized at all; that is, it is there that the so-called free magnetism is in evidence. But though it is perhaps not quite so obvious how to obtain proof of the statement, it is nevertheless true that it is the middle of the magnet that has the greater magnetization. Those who are familiar with the molecular theory of magnetization, which attributes magnetization to the alignment of already existing molecular magnets, should have no difficulty in realizing this fact, for it is clear that the reversing action of the free poles at the ends will tend to make the alignment less perfect near them. The fact that lines of force leave the magnet in the neighborhood of the poles also points to the same conclusion; for it indicates that there must be more lines passing through the center than near the poles, the rest having escaped. The simplest experimental proof is from the phenomena of induced currents. A coil of wire connected to a galvanometer is traversed by an induced current not only while the coil is being brought up to the pole, but while it is moved by stages over the magnet from pole to center. The induced flow is due to the change in the number of magnetic lines threading the coil, and the direction of the flow is that corresponding to an increase in this number, as the center is approached. The confusion, of course, is between magnetization and free magnetism. Near the center the magnetization is great, but practically no free magnetism shows itself, because north and south kinds are present together in nearly equal quantity. Near the ends the magnetization is less; but free magnetism, either north or else south, is conspicuous because there is very much more of one kind than of the other.—Knowledge.

ENGINEERING NOTES.

The recently opened Wocheiner Railroad, running from Trieste to Assling, in Austria, constitutes one of the most remarkable railroad engineering achievements in the world. The section opened is the first of a new route through the Alps to link up with the South German railroads, and it passes through difficult mountainous country. In the course of the stretch now opened for traffic forty-seven tunnels had to be bored, and 679 small and forty-nine large bridges constructed, one across the Isonzo River being among the largest stone arched railroad bridges in the world, the length of the span being over 270 feet.

With reference to locomotive grate area, the results of tests conducted at the St. Louis Exposition prove beyond question that the furnace losses due to excess air are not increased by increasing the area. In general, it appears that the boilers for which the ratio of grate surface to heating surface is largest are those of greatest capacity. A brick arch in the fire-box results in some increase in furnace temperature and improves the combustion of the gases. The loss of heat through imperfect combustion is in most cases small, except as represented by the discharge from the stack of solid particles of fuel. Relatively large fire-box heating surface appears to give no advantage either with reference to capacity or efficiency. The fact seems to be that the tube heating surface is capable of absorbing such heat as may not be taken up by the fire-box.

It is curious that in many respects the problem of producing a good gas engine and of designing the same is very similar to the problem which is involved when it is a steam engine that is to be built. The mean effective pressure and the initial pressure in the engine cylinders are different, regulation is more difficult, and the stresses in the working parts, although subject to the same laws, are far more unequal, but the balancing of the machine and the designing of the parts can be done by one who has a knowledge of the design of steam engines if he also knows something of the behavior of gas and the data connected with it. There are forces which are due to motion and there are forces due to mass, and added to these there are the forces brought into action by the explosion of the gas in the engine cylinders. The analysis of the results of these several forces and to see how they must be best withstood and how the machine shall work with a maximum of thermal and mechanical efficiency—that is the problem of the designer. But the responsibility of the man who is in charge of the plant and must work it must not be overlooked.

The first attempts at direct utilization of blast-furnace gas in engines were made in 1895. For a considerable time the gas had been burned in Cowper stoves for heating the blast for the furnace, and under the boilers which supplied steam to the blowing engines, and others serving the furnaces. It was natural, therefore, that the idea of directly employing it in gas engines should have occurred simultaneously to several engineers, notably to Lürmann and to Lencauchez, who had pointed out the blast furnace as a powerful gas-producer. Nevertheless, nowhere had any attempt been made to apply it to this purpose up to the end of 1894, when Thwaite proposed it to Mr. James Riley, of the Glasgow Iron and Steel Company. About the same time investigations were being made in Belgium and Germany, independently of Thwaite's experiments, which were not generally known on the Continent. The industrial world, which up to that time had hardly favored the idea, had thus been gradually prepared to receive it. The gas-engine, long restricted to small sizes and dependent upon the use of an expensive fuel obtainable only in large centers, now began to make headway. At the Paris Exhibition of 1889 two engines of 100 horse-power were shown and excited much interest among engineers. One had four cylinders, and was made at the celebrated works of the Deutz Company, and the other was a single-cylinder engine, exhibited by two French designers, Messrs. Delamare-Debouteville and Malandin. In the meantime the design of gas-producers had made important progress, completely freeing the new engine from its dependence on the gas works, enabling it to be installed anywhere, and to realize to the full extent its economic value by supplying it with a cheaper fuel. In 1892 Delamare installed at the Moulins Leblanc works at Pantin, a four-cycle, single-acting, single-cylinder engine, using producer gas, and developing 220 British horse-power, with a consumption of about 1 pound of coal per brake-horse-power per hour. Despite the difficulties met with in this bold attempt, it showed the possibility of economically producing high power with poor gas. The time had now arrived for engineers to pay attention to the use of gas from blast furnaces, which, although not of great heating value, was less costly; and was the more suitable on account of the progress which had been made in the design and working of blast furnaces, and proportionally lower consumption of coke, and, as a result, the marked reduction in the relative quantity of combustible gases, which only sufficed, with difficulty, to heat the blast and to produce the steam required about the furnaces. Finally, the progress of the science of heat had brought to light the causes of the low thermal efficiency of the steam engine, and notably of the loss resulting from the employment of boilers. It is not therefore surprising that the idea of dispensing with the boiler and burning the blast-furnace gases directly in the engine occurred, nearly simultaneously, in three countries, where metallurgical industry had made great progress.

SCIENCE NOTES.

A short time ago a Roman villa was unearthed in a wood at Brockwood Park, West Meon, Hampshire, which was found to be in an excellent state of preservation. When the excavations were completed it was found to occupy an area measuring 160 feet in length by 50 feet wide. The dwelling house contains a suite of nine rooms. Three of these rooms are floored with mosaic, while three others are paved with coarse red tesseræ. The flooring of the remaining rooms has completely disappeared. In one of the apartments the mosaic work is perfectly intact, and constitutes one of the finest examples of Roman work in this branch of decoration ever found in Great Britain.

In view of the use made in the course of the nineteenth century of Lagrange's generalizations (it may suffice to mention the theory of the potential, the Lagrangian equations of motion with their generalized idea of force, the general "principles" such as the principle of least action) it is not too much to say that Lagrange's work is as great an advance on Newton's as Newton's was on that of Galileo. By the contemporaries of Lagrange this advance was perhaps not fully appreciated. We find the physicists of the beginning of the nineteenth century still very strongly attached to the idea that all natural phenomena not only may, but must, be explained on the basis of Newton's laws by central forces acting instantaneously at a distance. Newton's mechanics had done such admirable service in astronomy that it had come to be regarded as the only possible means of describing and discussing the actions of nature. The gradual abandonment of this position and the change to the modern view according to which all actions in nature are transmitted through a continuous medium and require time for their transmission was accomplished only after a long struggle that occupied the greater part of the nineteenth century.

A new compound in the organic series has been recently prepared by M. Louis Henry, of Paris. This interesting hydrocarbon is the accessory product of the synthetic preparation of pinacolic alcohol, $(H_3C)_3 - C - CH(OH) - CH_3$ by the reaction of acetic aldehyde $H_3C - CHO$ upon the combination of magnesium with the tertiary bromide of butyl $(H_3C)_3 - CBr$ in ether. Evidently it is formed before the introduction of the aldehyde by the reaction of the bromide $(H_3C)_3 - C - Br$ upon the magnesium compound of the latter $(H_3C)_3 - C - Mg - Br$. We may no doubt obtain it more easily and with a better yield of the product, by the reaction of the hydrobromic ether of hexamethylethanol

$$\begin{matrix}(H_3C)_2C\,Br\\ |\\ (CH_2)_2\end{matrix}$$

upon the ether solution of methylbromide of magnesium $CH_3 - Mg - Br$. The new body hexamethyl-ethane is a well-defined solid of fine appearance, crystallizing from its ether solution in flat crystals like ammonium chloride. It has a sharp and very penetrating odor. This body evaporates and rapidly disappears in the open air. At a temperature of 14 deg. C. its vapor tension is equal to 0.8 inch of mercury. It melts at 103 to 104 deg. C. in a closed capillary tube and boils at 106 to 107 deg. As to the vapor density, it was taken in a Hofmann tube and found to be equal to 3.93. The calculated density is 3.939. This new hydrocarbon is of great interest from its physical properties and composition and also from the fact that it completes the series of double and symmetric methylation of ethane.

It was noticed by Herr Doerner that when metallic calcium was hammered on an anvil there was frequently a fairly violent explosion, accompanied by a flash of light and sparks, and it was found that the explosibility was promoted by the presence of rust on the anvil, or by traces of iron oxide as impurities in the metal. Prof. Cohen suggested that the explosion might be due to the calcium having absorbed gases, just, as is well known, platinum can do, and experiments showed that calcium was able to occlude a considerable amount of hydrogen. The more extensive observations independently made by Dr. Ohmann, and recently published in the Berichte of the German Chemical Society, suggest that in some cases, at all events, the explosion of calcium is due to a vaporization of the metal near the edge, where the pressure is greatest, and a combination of the vapor with the atmospheric oxygen. If the calcium be hammered in oxygen the flash produced is much more brilliant, while if the metal be struck with a rounded hammer only a faint light is observed, for then there is less vaporization at the edges. When several slight blows are given in succession there is an accumulation of heat, and eventually a gentle blow may then cause an explosion. Similar phenomena occur in the case of other metals. Sodium hammered on an anvil gives out a bright flash, and small yellow flames are sometimes produced. Potassium gives marked effects with almost every stroke of the hammer, small violet flames with clouds of strong-smelling vapors being formed, while small incandescent fragments may be split off by sharp blows. Lithium also gives brilliant flashes, frequently accompanied by a report and by sparks. The light emitted is much more intense than in the case of potassium. Powdered aluminium and magnesium only give small sparks, and do not explode. Of the non-metallic elements tried by Dr. Ohmann only phosphorus gave a positive result. It was expected that the blow would cause the phosphorus to ignite, but instead of this it was flattened out into a dough-like mass and emitted sparks.

TRADE NOTES AND FORMULÆ.

To Deaden the Brilliancy of Gilding with an Amalgam.—Cover the object with a mixture made of 46 parts of aluminate of potash and 3 parts of sea-salt in 5 parts of water; heat over a flame until the coating is almost transparent; then immerse in cold water, rinse with hot water and dry in saw-dust.—Moniteur de la Bijouterie et de l'Horlogerie.

To Remove Spots from Marble.—Make a rather thick paste of 4 parts by weight of soft soap, 4 parts of chalk, and 1 part of carbonate of soda mixed in sufficient water. Apply a quantity to the spot, leave for twenty-four hours, and then wash with pure water. The application can be renewed if necessary.—La Nature.

To Attach Handles to Pestles.—A cement for resisting the continual shocks which pestles undergo in a pharmaceutical mortar in a chemical laboratory, is prepared by making a fairly soft paste with litharge and glycerine, filling the hole for the handle with the paste and forcing in and keeping it under pressure for several days.—Drogisten Zeitung.

"Eclair" (Liquid for Cleaning.)—This is the rather ambitious name given to this product, which, it is claimed, will rapidly remove spots in woolen fabrics, giving brilliancy to black clothing, and which is good for the cleaning of carpets. Commence by dissolving 7.8 parts of soda and the same quantity of borax in a little water; add 31 parts of a strong solution of ammonia and 93 parts of a solution of potash soap with sufficient water to make up a total of 950 parts, when a preparation of 31 parts of ether and the same quantity of spirits of wine has been added.—Chronique Industrielle.

Cream for Cleaning Furniture, Marble, Leather and Other Objects.—This cream has been guaranteed to give good results by spreading it with a rag on the surfaces to be cleaned and rendered brilliant. The objects are afterward polished with a piece of flannel. To 1,500 parts of water add 25 parts of potassium carbonate and 2,500 parts of white wax; boil until an emulsion is formed. Replace the water lost by evaporation, stir gradually until the liquid is cold and add in small quantities, while stirring, 4,000 parts of oil of turpentine, so that an emulsion of the whole shall be produced. Finally, add a new quantity of water to make 4,500 parts of water in all and stir again.—Journal de l'Orfeverie.

Soldering Fluids.—First formula.—To ordinary zinc chloride prepared by digesting zinc scrap in chlorhydric acid until the point of saturation is reached, add 1/3 of spirits of sal ammoniac and 1/3 of water and filter; this liquid is particularly adapted for soldering iron and steel.

Second formula.—This is often called the Müller fluid. Mix 1 part of a solution of phosphoric acid with from 1 to 1½ parts of spirits of wine, of 80 per cent.

Third formula.—A good liquid may be prepared by mingling 1 part of lactic acid with 1 part of glycerine and 8 parts of water.—Zeitschrift für Oeffentliche Chemie.

Artificial Ivory.—It is said that this product is free from the danger of ignition, and can be used in place of celluloid although it contains a large proportion of cellulose. It is prepared with 43 parts of pure cellulose, the same quantity of powdered alabaster, 4 parts of gelatine and 10 parts of alum; these ingredients are worked up and run into a metallic mold, which is subjected to strong pressure. The product is dried, and the blocks immersed in a bath of wax and stearine. It is afterwards powdered by means of a fine brush covered with talc. This preparation, which is quite solid, and not much liable to change, may be worked like ivory.—La France Horologère.

Cement for Glass Capable of Resisting Liquids and Heat.—It should be unnecessary to say that this cement easily resists the effect of boiling water. It is composed of 100 parts of silver litharge, 50 parts of white lead, 3 parts of boiled linseed oil, and 1 part of copal varnish; the lead and litharge are mixed intimately, and the oil and copal separately. When the cement is to be used the two preparations are to be mingled in the proportion of 150 parts of the solid mixture and 4 parts of the liquid. The whole is worked up carefully and applied to the pieces to be fastened. These are kept closely pressed together for at least twenty-four hours.—Zeitschrift für Oeffentliche Chemie.

Adhesive Solutions and Compositions of Casein.—According to the Moniteur de Papeterie Française, solutions of casein are prepared in France by the Hatmaker process, which yield on drying an insoluble coat by the dissolution of the product in aqueous solutions of the hydrate or the oxide of barium or of strontium. In general, good results are obtained by dissolving 70 to 80 parts of casein in 20 to 30 parts of barium dissolved in sufficient water. The following examples are cited:

1. A dry mixture of 20 to 30 parts of barium hydrate and 70 to 80 parts of ground casein forms with water a strong glue, which becomes insoluble on drying.

2. A dry mixture of 20 to 30 parts of barium hydrate and 70 to 80 parts of dry casein, finely ground and well mingled, in order to be added to clay, talc, sulphate of baryta, etc., colored or not, forms a mixture for the sizing and finishing of paper. Barium oxide, or the hydrate or oxide of strontium may be used in equivalent quantities in place of the barium hydrate.—Drogisten Zeitung.

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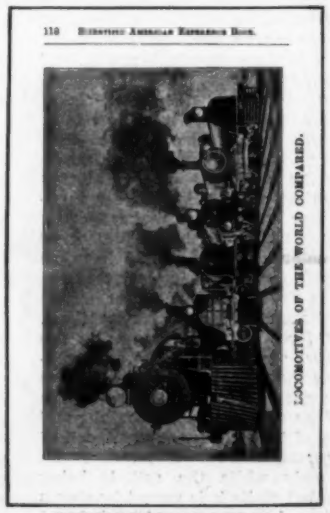
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